The Chemical Age

A Weekly Journal Devoted to Industrial and Engineering Chemistry

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VOL. XLI. NO. 1,070 December 30, 1939 Annual Subscription, 21s. Overseas, 26s.

Chemists and their Industry in War

WE are at war. The resources of the nation are being mobilised for action. Chemists and the chemical industries are obeying the call. This time we are largely organised in advance. The machinery of the D.S.I.R., with its specialised research laboratories and its large staff of men possessing the highest scientific and practical qualifications, was ready to transfer immediately from peace to war problems, and it has afforded a nucleus to which other scientists can be added and is capable of continuous expansion in any required direction.

Everyone cannot be called up for chemical service at once. The problems have first to be stated in a form which makes it possible to start work on them; also working places have to be organised. Waiting is irksome to the young man, but there is so much that he can do in the meantime. He need not sterilise himself because he has to wait.

If he looks around he will find on all sides many problems connected with the times awaiting solution. They may not be chemical, but at least they lend themselves to scientific approach. They are well worth thought instead of criticism. A chemist should not wait to be led or for somebody else to do something which he can pick holes in. At a time like this the facts must be faced, and there are too many signs among chemists of an inability to keep themselves such as the late Professor H. E. Armstrong used to deplore. The Government is blamed, for example, for not supplying materials which we can make for ourselves in the laboratory. We seem to have forgotten that our grandfathers had to make nearly everything—apparatus and chemicals. War stimulates inventions and the Government departments are known to be overwhelmed with such. This time a machine to deal with them is ready, thanks to the D.S.I.R., and there is no need for the Ministry of Inventions of the last war—a most unsatisfactory institution. Most of the stream of inventions and suggestions comes from people who are not technical, and it has been said that relatively few are from chemists.

Research on problems of national importance is also being organised by an Advisory Research Council of the Chemical Society which has both a main committee and Biochemical and Physical Panels. It is to be hoped that this body will receive and consider problems of a practical as well as of an academic nature.

Chemists in industry are faced in these times with the problem of finding a replacement for materials hitherto imported. They have also the development of new processes and the tribulations of controlling existing manufactures under war conditions. In many instances, also, they have assumed the duties of works A.R.P. official or have joined the Gas Identification Organisation. They may be described as fully occupied, perhaps almost too busy to leave themselves leisure to reflect and invent.

Complaint has been made in the past that scientists have been excluded from the Ministries, but this time men of scientific eminence are found in leading positions. The official control of many raw materials is also generally in the hands of men chosen from industry, as, for example, alcohol and sulphuric acid, to select two chemical industries. Perhaps the success of some of the controls where an expert is in charge may serve all the more to show up the failure in others where experts are ignored, which is properly receiving so much criticism.

It is possible to affirm that science has been effectively mobilised for this war, and that its advice and recommendations are being accepted as far and as fast as is possible in problems that affect the comfort and welfare of nearly 50 million people in a democratic country.

The work of chemical industry in war falls into several categories. There is first the manufacture of the essential war chemicals, explosives and the like. Nitration becomes of importance, also the manufacture of nitric acid. Economies in these operations now become of the utmost significance. Secondly, perhaps, come all those chemicals, largely the products of the fine chemical industry, which are required for the hospitals and medical and allied services. Thirdly is the great group of primary and partly processed chemicals which are required in the manufacture of all the materials for the offensive and defensive forces. Chemicals for tanning leather, for rubber, dyes and what not else for textiles, bleach for a dozen purposes, photographic materials, etc. The list could be multiplied to a lengthy one.

There is still the civilian population to be catered for; its food, its housing, its clothes, its safety. One

or many chemicals are required in every such process. In 1914 this fact was not known by the users; it was only when some process stopped for want of one ingredient or another, generally relatively insignificant from the point of view of cost, that it was realised that our chemical industry at home was insufficient. How different it all is to-day; we need no longer look to Germany for dyestuffs or to Chili for nitrates—the air around us gives all the fixed nitrogen that can be required in the form of ammonia. Perhaps the chemical industry is more nearly self-sufficient than any other; such gaps as there are are largely due to buyers going abroad for a small pecuniary advantage in spite of warnings as to the consequence. Such people hardly deserve sympathy to-day, though they are probably the loudest in their complaints.

Any analysis in detail as to what is being done, either in achieving normal or increased production or in making new products, would be improper from the national point of view. It must suffice that chemical firms are as busy as they can be, and though they may be rationing their customers this is due more to abnormal demand than to any lack of capacity to meet normally anticipated demands. At least there has been no need, as in 1914, to build and equip government factories to make substances for which there was a steady peace-time demand. In 1918 these factories were closed and dismantled, to our disgrace. It was still too early to establish the strong and self-supporting chemical industry which we now possess.

This is neither the time nor the place to job backwards, in Stock Exchange parlance, nor to assess which action, which person, which act of state played most part in the achievement of building up the strong chemical industry of to-day. The Association of British Chemical Manufacturers has played a greater part perhaps than is generally realised in bringing people together and so fostering co-operative effort. This is likewise not the time to vaunt our achievements: it is far better to examine our shortcomings, since these are going to be the problems during the coming months if this is to be a long war.

A war of exhaustion throws the onus very largely on the chemist and engineer, for they alone can conjure up the desired products out of the earth. We have already made the nitrogen and oxygen and other gases in the air available in any desired form. Perhaps now something may have to be done with sea water, though there is salt enough available on land. There is far too much waste material, and though a controller of this has been appointed the real problems are with the chemist who should be able to make something useful out of many waste products.

We do not make enough aluminium nor magnesium here, though fortunately this latter industry has been established in time. There is no calcium carbide produced, although the value of this material as a source of acetylene and the basis of organic syntheses is unique. The vested interests who have prevented, during the last two years, the setting up of this industry in Britain ought to be openly censored. But on the whole the gaps are few and involve but limited output, whilst in most instances the industry is known to be actively engaged in seeking to start their manufacture.

There are difficult times ahead, perhaps far more so than the man in the street, lulled by the past four months of security, is able to conceive. Chemists must be prepared to look ahead, to be ready for the worst. Just as we seek the medical doctor when we are sick, so the country will need the chemist to make substitutes in time of scarcity. It is foolish to use the word "substitutes," as people do, with a note of contempt; the time may well come when they will be thankful for them. The chemist must forget his analytical mind, cease to be critical of all men, and become wholly synthetical in outlook, constructive and sympathetic with his associates. In such way only will maximum assistance be rendered to the State.

1939

THE issue of THE CHEMICAL AGE presented herewith is, perhaps somewhat boldly, entitled an "Annual Review Number." For it is a difficult task indeed to write a review describing the progress in a year that has been sharply divided into two utterly distinct parts. In the first, chemists and chemical engineers, notwithstanding alarums and excursions, made strenuous efforts—indeed, redoubled their efforts—to get on with the normal and expected advances in research and in operation. In the second part of the year under review progress in research either came to a standstill, or else became diverted into the channels of military supply and therefore not available for discussion in the public Press.

Nevertheless, the distinguished chemists and engineers who have contributed to this issue of THE CHEMICAL AGE have been able to describe what has been done in various branches of the industry up to the outbreak of war; and the slight indications of subsequent work, which are all they are allowed to give, have a distinctly encouraging note auguring well for the progress of our military effort in this direction. Over the chemical trade in general there are remarkably few tears to be shed. Supplies of commodities, though in many cases well below normal, are for the most part very much better than at one time was expected; the position of the chemical worker is not unfavourable; and though the energies of certain key men may have been temporarily diverted into unprofitable channels, there has been no wastage of scientific personnel comparable with that of 1914.

One real benefit that we may look for as an outcome of the war—and one which should outlast all the horrors and discomforts that accompany war—is that the intensification of scientific research for military ends results in discoveries of permanent value under normal peaceful conditions. This was one of the few items that could be put on the credit side of the national balance-sheet after 1914-18, and in view of the amazing advances made in chemistry in the last twenty years it is not unreasonable to hope for a repetition. To those scientists and technologists who are engaged in purely war-time work at the moment we offer this thought as some small consolation.

A Message from the Chairman of the Association of British Chemical Manufacturers

I HAVE been asked, as chairman of the Association of British Chemical Manufacturers, to send a message to the readers of THE CHEMICAL AGE. The request comes at a time when, unhappily, the British peoples are at war. It is a tragedy for all of us that our great chemical industry, which is based on the patient research of an army of scientists over many years, and which has sought to apply knowledge so that the bountiful fruits of the earth may be utilised to the greatest benefit of mankind, should suffer diversion from its normal beneficent purposes. It is none the less a fact that the chemical industry is, and must remain, a main pillar of the national defence structure, and that with the advent of war some dislocation of the ordinary channels of trade is inevitable.

Mr. R. Duncalfe.

The fundamental part which the chemical industry must perforce play in our war effort was, of course, recognised by the Association long before war broke out, and steps were taken to provide the necessary organisation. This organisation in the wide field covered by the industry, which includes production of heavy chemicals, acids, explosives, fine chemicals, drugs and medicaments, dyestuffs and colours, coal and coal tar derivatives, fertilisers, insecticides, plastics and adhesives, fats and oils, and many other valuable commodities, is carried out by means of group control, all groups having representation on the central Council.

The Association has always maintained close touch with the relevant Government Departments; that touch is even closer to-day, and I am satisfied that the contacts made and the information exchanged are proving of great value to the nation and to the industry at the present time. Indeed, only in this way can be achieved the co-ordination and planning needed to develop the effort required for victory.

It will, I think, be obvious that under our present system of war economy, first consideration must be given to the demands of the fighting services and to the export which is essential to provide the currency we need for essential imports, but, at the same time, we are making every possible effort to meet the needs of the ordinary consumer. These are numerous and varied seeing that the chemical industry is perhaps the most fundamental of all industries, drawing its raw materials from the mineral, vegetable, and animal kingdoms below and upon the earth's surface, from the waters that cover the earth, and even from the air we breathe, and producing from them, in addition to many products complete in themselves, those other products which become the raw materials essential to most other industries.

At this point I should like to stress the fact that we realise to the full the necessity, following the dislocation in international trade due to the outbreak of war, of providing supplies of chemical products, including drugs, dyes, and fine chemicals, to replace those previously imported, and this is a field we are actively investigating. We welcome the co-operation of consumers, and I would ask them to communicate with the Association in regard to any difficulties experienced in regard to supply or by reason of shortage.

In the darkness of the present "blackout" let us draw comfort and inspiration from the reflection that our present distresses are but a phase in the long story of man; that the war, in which we are engaged and to the prosecution of which we must devote our utmost energies, will pass, and that man's inventive genius will again be devoted to the benefit of mankind. After destruction will come reconstruction in which chemical industry will play a leading part. For this, too, we must plan ahead, and the Association of British Chemical Manufacturers, which represents every branch of chemical industry will always be glad to receive contributions to the solution of these as well as war problems.

To all your readers, and particularly to the vast army of workers in all branches of the chemical industry, I send my best wishes at the beginning of the New Year, with the sincere hope that they and theirs may be preserved from harm, that the share of each one in our national endeavour may be crowned with success, and that, above all, during the year the dark clouds, now pressing so heavily upon the nations, may lighten, and the blessing of peace descend upon the world, bringing that freedom of mind which is the great longing of distressed humanity.

ROGER DUNCALFE.

Chemical Trade during 1939

IT is not proposed to follow the customary practice and refer to the trend of markets for the past year because no useful purpose could be served by making a comparison between the present abnormal conditions and those that were enjoyed in the early months of 1939. The period before the outbreak of hostilites is now forgotten and referred to as "pre-war." It may be said, however, that in the change-over from peace to war conditions the chemical markets on the whole remained remarkably steady.

In the early days of the war producers of chemicals, and merchants, many of whom were holding very useful stocks, wisely resisted the sudden expansion in the volume of buying orders from consumers who were anxious to build up already depleted reserves of raw materials. This policy enabled traders to continue to a very large extent to fulfil their engagements under existing contracts and deliveries to the chief consuming industries during the latter part of the year were reasonably satisfactory considering the many difficulties that had to be faced.

As was to be expected, a number of chemicals essential for war purposes are now controlled by the Ministry of Supply, but there is no reason to expect extensive price control.

In many directions steps have been taken to safeguard supplies of chemicals required in the production of war materials and in this respect the chemical industry is in a far happier position than in 1914. Many problems have yet to be overcome and some of these concern industries producing goods which do not come within the class described as war materials but are none the less important in the part they play in maintaining our export trade. Here a number of necessary raw materials are not readily available. The import position, however, is showing signs of improvement and there are indications that the gradual adjustment to war-time conditions will find a solution to some of these problems.

CONDITIONS IN, AND SOME WAR PROBLEMS OF, THE HEAVY CHEMICAL INDUSTRY IN 1939

By

P. PARRISH, F.I.C., M.I.Chem.E., M.I.Gas E., F.I.F., F.I.I.A.

Mr. P. Parrish was trained at the works of J. Brown & Co., Ltd., Tar Distillers and Chemical Manufacturers, becoming Manager, and later General Manager (1910-1914). He was subsequently appointed General Manager of the Egglescliffe Chemical Company Limited, Co. Durham. He joined the South Metropolitan Gas Company in 1915, as Manager of the Chemical Works. Mr. Parrish is the author of several books, and was an original member of the Yorkshire Junior Gas Association. He has contributed several papers to various technical societies.

Mr. P. Parrish.

COMMITTED to another grave struggle, the third within the author's active association with the heavy chemical industry, the year 1939 will signalise to future historians an epoch when the British Empire and its Allies declined to shirk their duty, but took up arms to defend freedom and liberty. No longer could the inordinate demands and disconcerting threats of an unscrupulous tyrant be tacitly accepted.

From Peace to War

In a single week this country prepared itself in a way little short of remarkable to receive any shock from warlike action to which it may be subjected. The change from normal to emergency activities was swift. Experience gained during the years 1914-1918 was invaluable. The heavy chemical industry knew—at least partially—what to expect, and how it should direct its energies to the best advantage. The dislocation of national life was far more severe than in 1914: yet there have been few panic decisions. In 1914 employers had to cope with indiscriminate recruiting for New Armies. This time sudden gaps necessitated by unexpectedly large demands for Civil Defence created problems calling for adjustments of staff, which, fortunately, were soon solved by the exercise of patience and goodwill.

The Minister of Supply at once appointed Controllers of many essential materials, such as iron and steel, non-ferrous metals, aluminium, wool, leather, timber, hemp, jute, paper, sulphuric acid, sulphate of ammonia, other fertilisers, and alcohol, molasses and solvents. The co-operation of traders was sought, and it was made clear that control would be voluntary, so long as no major problems arose.

Control of import and export materials was arranged. Annoyance was caused by delay in obtaining export licences for products which seemed to call for little, if indeed any, control.

The President of the Board of Trade early in September made it clear that the Government would use every effort to ensure that this country's exporting capacity was used to the best advantage, compatible with home markets and overriding war needs.

Thanks to the vigilance of the British Navy, Germany practically disappeared from the sea-borne trade.

The United States and Southern American markets had restricted access to German goods, while the doors of France and the British Commonwealth were tightly closed against German imports. This was, and still is, to the chemical and allied trades an opportunity to further and consolidate their trade. Such an opportunity should not be lost.

Compulsory war risk insurance had to be contemplated. There was a revised schedule of occupations, which removed few of the anomalies which characterised the previous edition. The value of the chemical engineer to the community was evident, as he alone, among his electrical, civil, mechanical and allied professional confrères was given a reservation age of twenty-one.

Patent and trade mark provisions, transport regulations (priority of transit by rail has to be given to consignments to and from naval, military or air force establishments), restriction of potash supplies, and conservation of fertiliser products, all called for careful consideration.

As regards enemy-owned patents, notice was given by the Board of Trade that correspondence with enemies in respect of patents, designs or trade marks would be permitted in approved cases: but communications would not be passed by the censorship authorities, except with the prior approval of the Patent Office.

Agricultural research in war-time is a necessity, and it was gratifying to have an intimation that the Research Council would work in the closest co-operation with the Minister of Agriculture and the Department of Agriculture in Scotland during the war, in connection with research investigations into problems that may arise from a food production campaign.

Steps to safeguard mercury supplies were inevitable, and could no longer be delayed. The vital importance of mercury and its compounds in medicine and industry (mercury fulminate is a detonator for T.N.T.-filled shells), is well known. This country, unfortunately, has no home-produced supplies. The use of the sulphide (vermilion) as a pigment calls for restriction, but other pigments, doubtless, will be found as substitutes.

The sale or supply of imported dyestuffs or intermediates not wholly or partly made in this country was prohibited as from October 13, except by a licence from the Board of Trade. In place of the old Licensing Committee an Advisory Committee has been appointed, consisting of one neutral, two makers' and three consumer nominees, all of whom served on the old Committee.

Industrial planning has been the subject of consideration by the appropriate Director at the War Office for some time now. It is understood that the A.B.C.M. is working in close association with this official, affording data of value regarding the chemical industry.

Importance of Aluminium

The foregoing presents a brief outline of some of the earlier changes from peace-time to war activities. But there are other verbal cameos to which reference must be made. An examination of technical literature during the last four years, and particularly recently, reveals how important the production of aluminium (for aircraft construction) has become. The production of aluminium is initially a heavy chemical process, and subsequently a metallurgical one. India has rich deposits of bauxite, generally of low silica, moderate iron, and high titanium contents. The industrial possibilities of this mineral have been reviewed several times, and it is considered that the Bayer process could be operated. Another process to utilise Indian materials, the basis of which is

fusion of a finely-ground mixture of barytes and bauxite, together with a small percentage of carbon at 1,400° C., and subsequent extraction, has been closely examined. On the other hand, the aluminium resources of Germany are constituted of siliceous ores, which do not lend themselves to treatment by the alkaline process. The British Aluminium Co., Ltd., has been active in the erection of factories.

Some High Explosives Problems

Early in 1936 the question of the processes to be adopted at projected explosives supply factories was under consideration. Government Departments were not inactive that year. What was foreshadowed in my review of conditions in the heavy chemical industry in 1936 was not without bearing on decisions ultimately reached. It was known that nitric acid, 96-98 per cent HNO_3, could be manufactured direct from ammonia and oxygen in a simple form of plant, involving a multiple gauze converter, waste heat boiler and a single bubble cap tower made of a special stainless steel.

In the absence of oxygen, nitric acid (50-60 per cent. HNO_3), could be manufactured in a multiple gauze converter having suitable oxidation and absorption apparatus. Fortification of the weak nitric acid could be effected in a denitration tower, the construction of which may embody the following features:—

A sectional earthenware tower, provided with perforated grids in each section, with a mild steel outer casing, the annulus between the outer circumference of the earthenware elements and the steel shell being packed and rammed with a mixture of acid-resisting cement and ground acid-resisting bricks. The bottom section is lined inside the earthenware with suitable obsidianite tongued and grooved tiles, the whole of which rest inside a heavy lead saucer, lined with acid and heat-resisting bricks and provided with an adjustable weir. The tower is packed with graded quartz. Quartz of a specific size must be used, otherwise there is a tendency for the feed of nitric acid and strong sulphuric acid to reach too rapidly the periphery of the tower.

It is not generally known that these denitrating towers possess appreciable flexibility as regards capacity, provided one can increase the pressure difference between the top and the bottom. The installation of a fan on the outlet of the tower aids such flexibility, which is invaluable under war conditions. One pound of steam should be consumed per pound of nitric acid concentrated, when the proportions are one of HNO_3 to three of SO_3 in the feed acids. Superheated steam is not necessary: one can reduce steam at boiler-pressure to say 20 lb. per square inch.

In the manufacture of T.N.T., nitro-glycerine and nitro-cellulose, water is a product of the reaction, and since this affects the concentration of the nitric acid, it must be removed progressively as it is formed. Invariably C.O.V. (96 per cent. H_2SO_4) is used for this purpose, and, due to dilution with water, waste acids arise, containing sulphuric acid and traces of nitric and nitrous acids. Because of the corrosive action of sulphuric acid of a strength lower than 73 per cent. H_2SO_4 on the nitration pots, the waste acid must be removed.

Waste acids vary slightly in chemical composition, according to the explosive manufactured. But they are invariably denitrated in a tower such as has been described, where further dilution occurs by reason of the application of steam in the denitrating process.

One of the problems of 1936 was to determine whether the $H_2O:SO_3$ balance could be restored by the addition of oleum, or whether concentration of weak sulphuric acid should be effected. Consideration revealed that the sulphuric acid balance would be seriously disturbed if oleum were used as a fortifying medium, since there is no loss of SO_3, either in the nitration process or in the subsequent denitration of the waste acids. The question then arose:—What type of acid concentrating plant should be employed? It was known that with the Gaillard concentrating tower, as indeed with the Kessler concentrating plant, it is difficult to attain a greater concentration than 93 per cent. H_2SO_4, if a satisfactory rate of production is to be secured. The decision was ultimately forced upon one that the concentration of weak sulphuric acid in cast iron pots, such as was illustrated in my review (CHEMICAL AGE, 1936), should be adopted. Many large plants involving scores of units, each of twenty tons per day capacity, have been erected.

What has been the general experience of the operation of this type of plant? Cast iron pots, as manufactured in this country from close-grained iron, with the introduction of a well-defined small percentage of nickel, etc., have proved as satisfactory as any of the cast iron pots made in Germany. The cast iron pots should be left in the open to oxidise and mature before being used. All cast iron pots reveal signs of corrosive attack when put into operation initially. One should not be unduly alarmed at this, but should continue to maintain a pre-determined uniform temperature and rate of working. After a limited period of 12 to 36 hours the cast iron pot forms its own protective coating and the corrosion subsides, once a non-corrodible film has been formed. Stirring of the acid undergoing concentration in the cast iron pots does not break the protective coating, but affords a distinct advantage, presenting, as it does, fresh quantities of acid to the hot walls of the pot. A stirred pot has a sensibly greater throughput than one which does not provide for agitation of the acid.

Experience suggests that the life of the cast iron pots may well be of the order of three years—in some cases even more. That this form of acid-concentrating plant has fulfilled the hopes entertained seems manifest.

One of the disabilities of the cast iron pot type of concentrator is the large quantity of acid—about 10 to 12 tons—undergoing concentration. If a fracture occurs, even assuming the fire is withdrawn, or the producer gas supply is cut off, the sensible heat of the brickwork setting is such as to volatilise the escaping acid, and cause considerable nuisance:

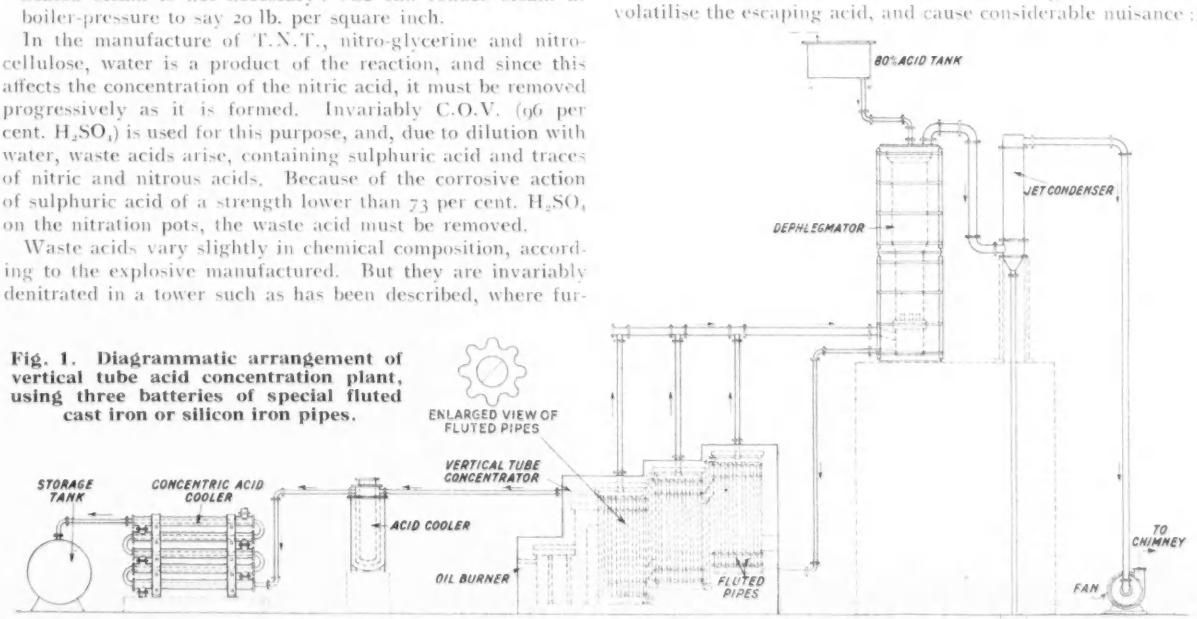


Fig. 1. Diagrammatic arrangement of vertical tube acid concentration plant, using three batteries of special fluted cast iron or silicon iron pipes.

if the fracture is a serious one, the consequences will certainly be pronounced—indeed, more pronounced than the worst of the "white chimneys" associated with the basin type of concentrator familiar to many in the Great War.

What is represented in Fig. 1 is a complete acid concentrator, designed by the author (B.P. 495,715), of the vertical tube type. Three banks of twenty-four each 2 in. internal diameter fluted tubes will yield 10 tons of 96-97 per cent. sulphuric acid per day of 24 hours from 70 per cent. recovered waste acid. The outstanding features may briefly be summarised as follows:—(1) Silicon iron or cast iron can be used for the construction of the tubes and manifolds. (2) The quantity of acid in the three banks of twenty-four tubes is 24 cwt., as contrasted with 12 tons in a cast iron pot concentrator of equal size. (3) All the pipes are renewable. (4) The surface area available for heating is 540 square feet, as against 135 square feet in the cast iron pot concentrator. (5) If steam is required at the factory where this vertical tube acid concentrator is adopted, a waste heat boiler can be installed, to reduce the sensible heat of the products of combustion emerging from the concentrator from say 55° C. to 250° C.

Chemical engineering development of the last twenty years has rendered possible the nitration of phenol (synthetic or coal tar) and toluene with nitric acid, in a continuous manner, thus removing the hazards associated with the discontinuous operations of former days, where large batches of potentially dangerous materials existed. In war-time, apart from actual explosives products, materials such as potassium, barium and strontium nitrate, activated carbon, hydrogen peroxide, aniline and benzoyl chloride, oleum, sodium and potassium chlorates, irrespective of others mentioned elsewhere in this review, are required. Limitations of space render it impossible to deal with all these products. But the importance of activated carbon at the present juncture calls for some epitomised but more detailed reference (see below).

Certain crude (petroleum) oils contain interesting amounts of aromatics. Extraction can be effected with liquid SO_2 or by phenol compounds or other substances with partial valencies. These extracted aromatics, after purification and fractionation, can be nitrated, and form excellent nitro compounds, such as T.N.T. This country derives supplies partially from the above source: but transport difficulties render imperative increased quantities of indigenous toluene, to which reference is made later.

Activated Carbon

Activated carbon, apart from being the active element in respirators, is used in benzole recovery, solvent recovery, water purification, and for decolorising. The normal consumption for these purposes is between 1,500 and 2,000 tons per year, but war conditions have increased the demand enormously. Already several thousand tons of active carbon have been used in connection with civilian-pattern respirators. Active carbons can be prepared from most woods and vegetable residues, although coconut shells have so far been found to yield the best product. The cells of the nut charcoal are much more dense than those of wood charcoal, and the fine pitting of the product is responsible for its superior activity. Charcoal of this type is used almost exclusively for respirators. In the decolorising of sugar, where a cheap material is required, bone charcoal is almost universally employed.

Activation of carbon is now usually effected by superheated steam at 700-950° C. The quality of the carbon increases with increase of steam consumption, but the yield is inversely affected. The action of the steam is two-fold (a) oily hydrocarbons are removed, and (b) reaction with the carbon base occurs, which promotes porosity.

The present extreme urgency of providing active carbon in large quantities has led to an investigation by the Fuel Research Station into the suitability of British coals for this purpose.

Another potential source of active carbon is surplus cane sugar molasses, the utilisation of which has been engaging the attention of numerous investigators in India. The suggestion for preparing active carbon from this material comes from the University College of Science at Calcutta. The yield of carbon is said to be 30 per cent., and preliminary work is stated to have shown encouraging results.

Synthetic Ammonia

It has been emphasised in former reviews that more and more synthetic ammonia plants were being erected. Only last year plants for the manufacture of this product were reported in course of construction in Finland, Mexico, Baroseve (Jugoslavia), while the state-owned nitrogen works at Diesogentmarton (Rumania) had received a state grant.

Nothing of importance has been reported during the year in the matter of improvements of technique. The author has been asked frequently to give the position regarding the production of synthetic ammonia in Greater Germany, as contrasted with this country. The figures are shown opposite, but those relating to Greater Germany must be regarded with some reserve.

Fuel and Gas Industries

The fuel and coal-carbonising industries are of vital importance in times of war, just as they are of unique service in peace.

The war has rendered impossible the publication of important advances of technique, relating to the gasifying of certain coals in hydrogen, and the increased yield of hydrocarbon (at above 800° C.) which accompanies such a process. What the ultimate possibilities are may now be tolerably well known, but obviously any announcement at this juncture would be imprudent. The value of the gas and coking industries in times of emergency is strikingly revealed in some figures given by Sir Harold Hartley, C.B.E., in a paper to the B.C.G.A. conference at Brighton in April last:—

Benzole	50 mil. gal.
Sulphate of Ammonia	350,000 tons.
Sulphuric acid (from spent oxide)	220,000 tons.
Tar	Over 2 mil. tons.
yielding:—	
Road tar	700,000 tons.
Pitch	600,000 tons.
Creosote	90 mil. gal.
Naphthalene	30,000 tons.
Cresylic acid	20,000 tons.
Toluene	5 mil. gal.
Xylenes and solvent naphthas	5 mil. gal.
Pyridine bases	4,000 tons.

Benzole Recovery

Not all gas undertakings are recovering benzole at the present time, but the erection of plant is being expedited at those works which hitherto had no recovery plant. When it is recalled that benzole contains about 15 per cent. of toluene, suitable for nitration, some additional tangible evidence of the utility of these industries is afforded. It is interesting to observe that nitrating toluene should distil 5 to 97 per cent. between 110.2° and 110.6° C.

The clamour to-day for more ammonia, benzene, sulphur and toluene, which products collectively can alone be obtained from the carbonisation of coals under high-temperature conditions, is incompatible with the Fuel and Lighting Order, which was originally designed to enforce a 25 per cent. reduction. It is imperative that there should be a restoration of a reasonable measure of street lighting, and the *Daily Telegraph's* timely demand for the return of evacuated businesses should meet with full response.

Proposals have been made to modify carbonising conditions at coke oven plants, with the object of increasing the yield of benzole, by fitting roof channels to the ovens, and maintaining an oven crown temperature of 600-800° C. A 10 per cent additional yield has been foreshadowed. Various methods for controlling cracking in the gas space have been reviewed by G. J. Greenfield.

Patent literature reveals that the avoidance of loss in the

Synthetic Ammonia Production :

Location.	Firm.	System.	Annual capacity Net Tons Ammonia.	Origin of Hydrogen.
	GREAT BRITAIN.			
Billingham-on-Tees	Imperial Chemical Industries, Ltd.	Haber (250 atmos.)	206,400-	Water gas.
Flixborough	Nitrogen Fertilizers, Ltd.	Mont-Cenis	13,000-15,000	Coke oven gas.
	GREATER GERMANY.			
Germany.				
Leuna (Merseburg)	I.G. Farbenindustrie, A.G.	Haber-Bosch	728,500	Water gas.
Oppau	I.G. Farbenindustrie, A.G.	Haber-Bosch	151,800	Water gas.
Sterkrade-Holten	Ruhrchemie, A.G.	Casale	24,300	Coke oven gas.
Rauxel	Gewerkschaft Victor	Claude	30,400	Coke oven gas.
Waldenburg	Ammonium, G.m.b.H.	Nitrogen Engineering	19,400	Coke oven gas.
Harten	Gewerkschaft Ewald	Nitrogen Engineering	19,400	Coke oven gas.
Scholven	Gasverarbeitung, G.m.b.H.	Mont-Cenis	26,700	Coke oven gas.
Sodingen	Gasverarbeitung, G.m.b.H.	Mont-Cenis	34,000	Coke oven gas.
Piesteritz	Mitteldeutsche Stickstoffwerke, A.G.	Fauser	7,300	By-product water gas.
Czechoslovakia.				
Ignatz	Société Tchécoslovaque de Produits Azotes	Claude	12,100	Coke oven gas.
Aussig	Verein für Chemische und Metallurgische Produktion	Nitrogen Engineering	4,000	Electrolytic by-product.
Poland.				
Knurow	Société Fermière des Mines Fiscales de l'Etat Polonais	Claude	16,000	Coke oven gas.
Wyry, Upper Silesia	Ammonia, A.G.	Nitrogen Engineering	19,400	Electrolysis of water.
Chorzow, Upper	Pantswowa Fabryka Zwiazkow Azotowych (State Nitrogen Plant)	Nitrogen Engineering	9,700	Water gas.
Móscice (Tarnovie)	Zwiazkow Azotowych	Fauser	21,300	Water gas.

refining of crude benzole has been the subject of continued attention. References have been made during the year to (a) the Niggemann's process, (b) the Rostin process and (c) methods developed at the Fuel Research Station. The Fuel Research Board's process is virtually one involving desulphurisation of benzole by means of mild hydrogenation. Pelleted molybdenum disulphide is the most suitable catalyst, and it is found that the benzole can be satisfactorily desulphurised, without causing reduction of catalyst activity, at a temperature of 350° C., and at a pressure of 20 atm.

The continuous type of tar distillation plant has continued to operate with success. Those systems which have been installed are the Koppers, Wilton and the Foster-Wheeler. These new plants are bound to have their teething troubles, of which erosion or corrosion is known to be one, because of the high liquid and gas velocities.

Sulphur and Sulphuric Acid

The following figures, which relate to the entire industry of Great Britain and Ireland, show the production (and the consumption of raw materials by the industry) for 1930 and the last three years. They are given in this form so that attention can be directed to certain aspects of importance.

Year.	Acid made (chamber and contact) in tons of 100% H_2SO_4	Percentages made from				
		*Pyrites and others		Spent oxide.	Brimstone and H_2S.	Zinc concentrates.
		Imported.	Domestic			
1930 ..	850,000	50.16	0.61	25.33	13.98	9.92
1936 ..	1,043,000	49.07	0.13	21.40	16.71	12.69
1937 ..	1,100,000	46.56	0.15	20.41	21.25	11.63
1938 ..	994,000	46.65	0.17	20.29	21.38	11.51

In the column headed " *Pyrites and Others " is included not only pyrites but also the tonnage of anhydrite consumed in this country in the manufacture of sulphuric acid after having been converted into the " equivalent " tonnage of pyrites.

The statistics in question reveal the growing use of brimstone as a raw material in the manufacture of sulphuric acid. In times of emergency transport is always an uncertain factor. Sufficient importance is not attached to indigenous sulphur materials. There are three potential sources of sulphur in this country, (a) spent oxide, (b) SO_2 of metallurgical gases and (c) anhydrite. In normal times the quantity of sulphur recovered per ton of coal carbonised is of the order of 12 lb.; but in the Great War, owing to shortage of labour at the picking belts, more brasses than usual found their way into the coal, with the result that the sulphur recovered per ton of coal carbonised was of the order of 20 lb. While gas undertakings should not be called upon to bear the financial burden of recovering increasing quantities of sulphur without suitable recompense, means are clearly at hand to augment supplies of sulphur materials.

As regards the SO_2 of metallurgical gases, many processes are available, and these have been dealt with in the author's annual reviews in THE CHEMICAL AGE from time to time. In this connection it is interesting to remark that the production of elemental sulphur from the smelter gases at Trail, B.C., is continuing to grow. The process employed is virtually the recovery of SO_2 in ammonia, the acidification by sulphuric acid of the resulting ammonium sulphite and the reduction of the evolved concentrated SO_2 in a suitable coke furnace to sulphur and accompanying derivatives. Additional plant at Trail is in course of erection, which will increase the quantity to about 200 tons per day.

The international pooling agreement of sulphur recovery patents was announced in April last. This concerns the basic aluminium sulphate process of I.C.I., the Bolidens Gruvaktiebolag process for direct reduction of weak SO_2 from smelter gases (production 70 tons per day), the " Ciba " (Chemische Industrie of Basle), which developed a process

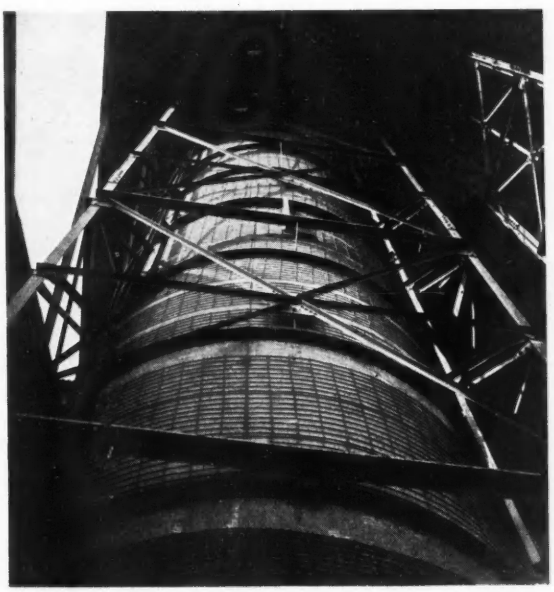


Fig. 2. Tower showing the reinforcement of the lead by means of special wire.

for concentrating SO_2, in which the absorbing medium was an emulsion of an aromatic amine in water, and the Metallgesellschaft A.-G., of Frankfurt (its subsidiary, Lurgi-Chemie), which had built plants in Germany, 5 tons per day SO_2 capacity, and in France, 30 tons. Lurgi had also developed a process for direct reduction of SO_2 to sulphur. Sulphur Patents, Ltd., was formed to act as sole agent, to negotiate licences for the Companies.

As regards the recovery of sulphur from anhydrite, the author dealt in some detail with this question in 1929, in an article appearing in *The Industrial Chemist*.

Gordon S. Duncan, in a talk on Cyprian pyrites to the Colonial Empire Marketing Board, remarked that the output of the mines was one million tons annually, of which about 700,000 tons were dealt with in the concentrator, to produce 20 per cent. copper concentrates.

Modifications of the chamber process, directed to more intensive working, and a sharper discrimination of the production, and oxidation, sections of the process, are recorded. One such process is described by Soc. Gén. Métallurgique de Hoboken. Packed towers are employed for production and absorption, and an intermediate void space is furnished for the regeneration of the nitrous oxides. This regenerating space is sprayed with a dilute solution of nitrose of constant concentration, the density being maintained at 1.45 to 1.56, and the nitrosity at the equivalent of 0.3 per cent. nitric acid. In employing the nitrose method the towers are sprayed in two independent circuits. The outer circuit, comprising the first and last towers, is fed with acid of approximately 1.70 density. The inner circuit comprises two towers, between which a space is provided for regeneration. This circuit is fed with acid of approximately 1.65 density. The towers are packed with material of low free-space/surface ratio, so as to minimise the regeneration of nitrous oxides in the production section. The regeneration space, which may be arranged below or above the packing of the intermediate towers, or may consist of a separate tower, is either void or filled with packing of high free-space/surface ratio material.

The control of plant conditions has been appropriately dealt with by H. D. Greenwood, who describes an apparatus for the continuous measurement of the acidity of the exit gases of a sulphuric acid plant.

Under emergency conditions the capacity of most sulphuric acid plants in this country can be increased by the adoption of the Gaillard-Parrish liquid phase system, using turbo dispersers. But turbo dispersers are not less applicable to rectangular chambers than to towers. Fig. 2 is interesting, as illustrating continental tower construction, the distinctive feature being the use of an armature of metal wire netting, covered by B.P. 359,368, which ensures the lead being maintained in position, and thus minimising the growth of lead sulphate-containing nitrous bodies behind the lining. Such growth has a distinct corrosive influence.

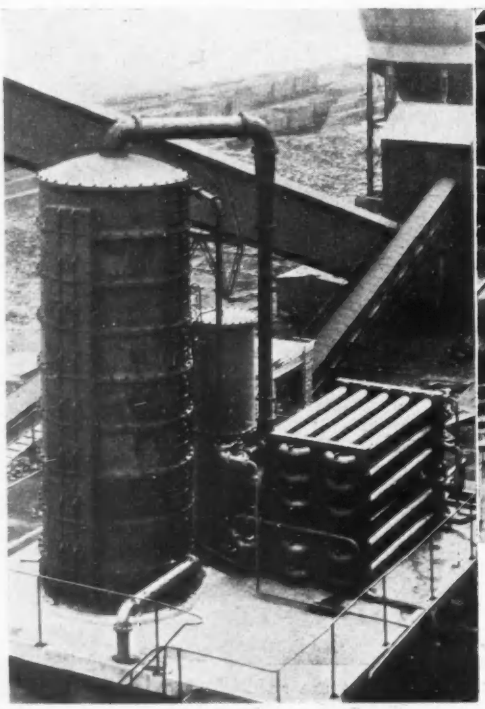
Several oleum plants have been erected in this country during the last three years, all dependent on sulphur as a raw material. Investigations of the conditions of catalysis with various materials and methods for their preparation have been published. It is found that power costs can be reduced by careful design. The ideal converter should not be of uniform diameter, nor of a uniform contact mass-grain size. Finely-divided catalyst, and comparatively narrow tubes, are to be preferred at the inlet, the grain size and tube diameter increasing towards the outlet.

The production of nitric acid is indispensable to the pursuit of any war. This manufacture should be as widespread as possible, for obvious reasons.

There are several processes covered by patents for the simultaneous production of sulphuric and nitric acids. Concentrated gas liquor can be distilled, the necessary air or air-oxygen added, and combustion effected at the converter, using platinum, or preferably platinum-rhodium, gauze. Nitrogen oxides result from the oxidation of ammonia, and SO_2 is the combustion product of H_2S and air. Sulphur dioxide oxidises, in the presence of excess air and nitrogen oxides (acting as a catalytic medium), to SO_3, which condenses with steam, and forms sulphuric acid. Thus, a mixture of sulphuric and nitric acids is obtained. It is an easy matter to separate the sulphuric acid, by transferring the mixed acids to a denitration tower, using C.O.V. as the dehydrating agent, but otherwise operating normally.

The Kachkaroff-M.P. process, to which reference was made in my review last year, is still peculiarly attractive in this connection. It must make an appeal to those who require sulphuric and nitric acids, particularly where there are variations in demand. The Kachkaroff-M.P. process can be

(*Continued on page* 450)



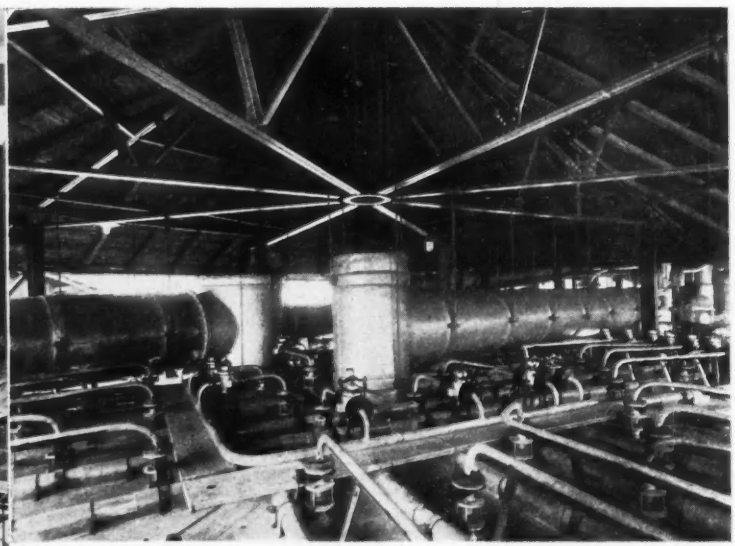


Fig. 3 (right). Distributor arrangement in connection with a large Kachkaroff-M.P. sulphuric-nitric acid plant. Fig. 4 (left). Large concentrated gas liquor plant, vapour phase process, dealing with 2,600 gallons of gas liquor per hour, and producing concentrated gas liquor 22% by weight.

THE WAR AND THE CARBONISATION INDUSTRIES

By

G. E. FOXWELL, D.Sc., F.Inst.P., F.Inst.F., M.Inst.Gas E.

Dr. G. E. Foxwell entered the by-product coking industry in 1912, *and has occupied many important positions in the coke oven and gas industries. His researches on the plastic state of coal and on the mechanism of coke formation have gained him international recognition. Since* 1932 *he has devoted himself to consulting work, and is now London manager to the well-known firm of Gas, Chemical and General Engineers, Messrs. Clayton, Son & Company, Limited, of Leeds.*

Dr. G. E. Foxwell.

IT is sometimes denied that the carbonising industries are properly a part of the chemical industry and in past years this doubt has received expression by the non-inclusion of the carbonising industries proper in the annual review number of THE CHEMICAL AGE. The present writer has no doubt that the carbonising industries are in one sense no nearer than first cousin to the chemical industry, but in another they are actually of the same household. It is true that the major product of every branch of the carbonising industries is not strictly a chemical, whether that major product be coke or gas. On the other hand, these industries employ large numbers of chemists, they are well to the fore in the extent of the chemical research work undertaken by them, and if one takes the trouble to draw out a diagram of a complete by-product coking plant including coal washery, coke oven installation, benzol plant and tar distillation, it will be found to comprise at least one example of practically every operation of chemical engineering. There can be few processes so comprehensive in this respect.

The effects of the war—actual and potential—upon the different sections of the carbonising industries will be different. The coke oven industry has been materially affected by the war from the time when it first seemed possible that another international conflict would occur. It is pre-eminently a key industry. National safety and national economics demanded the re-organisation of our iron and steel industry. In that re-organisation an essential part was the installation of modern by-product coking plants at great self-contained iron and steel works, the ovens being arranged for heating by their own gas or blast furnace gas at will, thus liberating all the coke oven gas for use in the steel works. That has divided the coking industry into two parts, one of which is part and parcel of the iron and steel industry while the other is part of the colliery or may be occasionally an independent company. This second part of the industry manufactures coke for metallurgical purposes when required, but is tending to specialise more and more upon the great coke market that is being opened up by the demand for solid smokeless fuel for domestic uses and for certain industrial purposes. In order to carry on this part of the business successfully it was found necessary to organise the marketing of coke on modern scientific lines—as had already been done for years in the London and Southern area by the gas industry—and a new co-operative movement sprang up in the coking industry which promised, and still promises, new strength and stability for the future. Perhaps this is the most important happening in the industry for the last decade.

Fluctuating Demands for Coke

During the boom period two events had taken place which reacted adversely upon the fortunes of by-product coking. The industry was not yet imbued with the understanding of the modern concepts of marketing and those who were entrusted with selling coke all too often believed that the principle to be adopted was that of the past generations, namely, to get as high a price as the buyer could be made to pay. The result has always been a lack of stabilisation and long periods of short time and low output alternating with shorter periods of great prosperity. Consequently when the demand for coke was at its height, prices soared to uneconomic levels, and this obviously drove the iron and steel industry to avoid the use of coke wherever possible. In addition, supplies of pig iron and scrap were short, so that in March, 1937, the import duty on pig iron was entirely removed by the Treasury and was not re-imposed until May, 1938. In the interim the country was flooded with imported pig iron and it was clearly seen that high coke prices had killed the goose which had been laying golden eggs for a few short months. For years the coking industry, impelled by economic necessity, had been contracting to supply gas to gas undertakings. Although the demand for metallurgical coke had fallen to a low level, and although mild winters had reduced the demand for coke for domestic uses and for export, it was still necessary to operate the ovens to supply gas to towns under contract. The result was that huge stocks of coke began to accumulate, so mountainous as to challenge comparison with the local scenery. Some salesmen, still not fully modernised, tried to dispose of this coke at gift prices, but found that the organisation of the gas coke industry was sufficiently strong to resist the invasion, and thus began to realise that a proper coke organisation was a necessity under modern industrial conditions.

Precautions for the Future

In one sentence, the effect of the war has been to cause the demand for coke to increase so greatly that already most of the stocks have been sold and preparations are being made to produce every ounce of coke that can be made. The moral of the recent past history is that the steps which are being taken to set up proper coke marketing organisations throughout the country both for the coke and gas industries individually and in combination must be actively pursued so that, when the inevitable slump in metallurgical demand comes, both industries may be prepared to deal with the surplus coking capacity upon sound lines and thus avoid the chaos that would otherwise descend upon them.

During the last war, 1914-18, the coking industry constructed many new plants and in particular many additional benzol plants. A writer of 1914 (probably the late Stanley Cooper, on whose staff the writer then was) said: "The average yield of benzol taken over the whole country is certainly not more than 2½ gallons of crude spirit per ton of coal. . . . At the present time there are not more than 7,000 by-product ovens in operation and not more than 6,000 ovens recovering benzol. Taking the average carbonising capacity of an oven as 1,650 tons per annum, and 1.8 gallons of motor spirit per ton, we get as the possible production of benzol, 17,820,000 gallons." In those days about half the metallurgical coke was still produced in beehive ovens, and

the major change during the war was the replacement of most of the beehives by by-product ovens. Most of the beehives were probably kept in operation until the end of the war, but whereas in 1913 there were 13,167 beehives at work, by 1920 the number had dropped to 5,384.

No such change is likely to occur this time. The figures in tons for significant years are as follows:—

Year	Pig iron produced	Consumption in blast furnaces coal used	coke used
1913	10,260,315	21,223,607	
1914	8,923,773	18,381,106	
1915	8,723,560	2,509,456	9,746,743
1916	8,919,469	2,612,543	10,300,888
1917	9,338,104	2,816,318	10,961,734
1918	9,107,384	2,606,840	11,286,680
1935	6,424,100	116,200	7,099,200

Coke production in recent years has been as follows:—

Year	Tons
1935	12,755,205
1936	14,819,914
1937	16,097,080
1938	13,855,514

The president of the Coke Oven Managers' Association, Mr. T. Long, has stated (October, 1939) that "With the ovens which are now in operation, and those ready for use, the production would be 20,228,530 tons." Evidently, by comparison with coke consumption in 1918, there does not appear to be any likelihood at the moment of a vast building programme during this war; we have done our building in advance this time.

Likewise we are in a much better position as regards benzol than in 1914. The report of the Falmouth Committee gave the total crude benzol production for 1936 as 82,970,000 gallons or more than three times the production for 1914.

This increased benzol production is partly due to the recovery of benzol in the gas industry, although the production from coke ovens is about 2½ times that from gas works, partly because not more than 50 or 60 per cent. of the coal carbonised in gasworks is treated for benzol recovery, and partly because most gas undertakings do not remove benzol completely from the gas. Here, again, we have been forestalling events by constructing most of the benzol plants required in advance of the emergency for which they are needed. There are perhaps half a dozen very large gasworks benzol plants which will not be in operation for a few weeks and probably our 1940 crude benzol production will be in excess of 100,000,000 gallons.

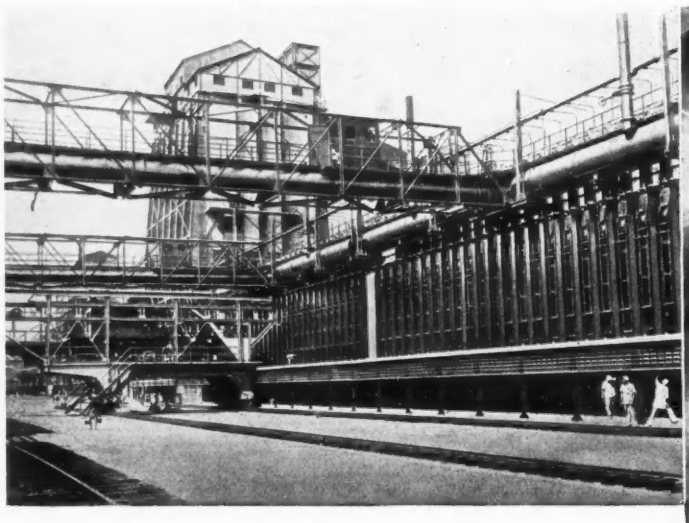
The effect of war on the gas industry can be stated more shortly than for the coke oven industry. There have been, though not from war causes, advances in the price of coal that beggar all precedent and that increase the price of gas and coke. This grave handicap to the growing Smoke Abatement Movement is being offset as much as possible by increasing the efficiency of gas utilisation. Research work must, however, be largely slowed down by the stress of more important affairs. The gas industry only produces benzol, coke, tar and ammonia—all needed for the defence of the country—in proportion as it can sell its gas. In all districts there has been a decrease in gas output due to the discontinuance of street lighting. In some districts there has also been a decrease due to evacuated people having left them for supposedly safer areas. Naturally the gas undertakings in these areas cannot do otherwise than carry on with their reduced output, hoping meanwhile that some or all of it will be recovered by increased consumption of gas by industry. In the areas to which people have been evacuated, the demand for gas has been increased, but the problem here is rather to avoid having to erect new and costly plant to deal with a temporary population that may leave the district at any time and will certainly leave as soon as war ceases.

It is too early yet to write of the possible effects of the war on low temperature carbonisation. Existing production is likely to be well maintained, and one large new works has been put in operation this year. A large low temperature coke oven plant has also started production. The writer does not know of any other large schemes for new plant. Aviation spirit is produced from low temperature tar oils, but not in sufficient quantity to warrant erecting plants for this purpose alone. The greatest possibilities for the extension of the process at the moment lie in the provision of solid fuel for traction purposes. It is common knowledge that the Government has now removed the crushing disabilities that prevented the development of the suction gas producer in this country for motor traction; vehicles provided with producers are now becoming a common sight. We import in time of peace about 11,000,000 tons of petroleum products annually. If we assume than only the heaviest civilian buses and lorries would be transformed to burn solid fuel, we may take at least 1,000,000 tons of this oil as readily and immediately replaceable by solid fuel. That means that we require nearly 2,500,000 tons of fuel. There is available not more than 500,000 tons of anthracite, and probably less. The only other fuel suitable is specially prepared low temperature coke. If the producer-fired vehicle becomes popular and appears likely to outlast the war, and if no means is found of using high temperature coke for the purpose—two important "ifs"—a large extension of low temperature carbonisation will be necessary to provide the fuel.

Perhaps one cannot be too definite as to the effect of the war on the tar distilling industry. It is evident that certain materials, especially those which can be used for munitions, will be in great demand. Phenol, cresol, benzol, toluol and xylol will be amongst these. Evidence of this is to be found in the fact that plants for the production of nitration quality toluol have been or are being erected at many coke ovens and gas works. To that extent the tar distiller is forestalled by the primary producer, but, of course, the tar distiller has plenty of crude benzol from the smaller works to keep him busy. Creosote should be in good demand, especially for hydrogenation to lighter spirit. Pitch, however, may well be difficult, though, if memory serves aright, it rose during the last war to £9 a ton. Particulars have been published of an interesting process by which vertical retort tar can be converted by a simple and inexpensive operation into material of the very highest quality possessing quite unusual properties. More is likely to be heard of this in the future. The pipe still method of tar distillation is proving very popular and is displacing the pot still. To a great extent the methods of tar distillation are those of past generations, hardly altered, and compare very unfavourably with the modern plant and technique of the petroleum refiner. The time has surely come for a change. Koppers' pipe still plants have been erected recently at the Beckton tar works of The Gas Light and Coke Company, at the Orgeave coking plant of Rothervale Collieries, Ltd., both these being of 400 tons a day capacity, and at the Yorkshire Tar Distillers, this being of 200 tons a day. Wilton pipe still plants have been installed at many works, including, among recent installations, one of 150 tons per day for the Powell Duffryn Collieries, and there are under construction a plant of 100 tons a day for the South Yorkshire Chemical Works, and one of 75 to 100 tons a day for the Scottish Tar Distillers. It is anticipated that the effect of the war will be to create additional demands for tar products, and if these products are to be produced quickly and of the best quality, the modern pipe still must be adopted in place of the old and slow pot still.

Advance of Petroleum Technology

It is more difficult to forecast the future, but it seems morally certain that the tar distillation industry will have to face direct competition from the petroleum industry. At one time these industries seemed to be widely separated by the gap between aromatic and aliphatic compounds. To-day that gap has been made to disappear by reason of the great research organisations of the petroleum industry. As one example of the trend of petroleum technology, a quotation is here given from a paper by H. S. Taylor and J. Turkevich (Trans. Faraday Soc., 1939, p. 921): "For the bulk produc-



Above : Battery by-product coke oven recently completed by Messrs. Simon-Carves, Ltd., for the Tata Iron and Steel Company, Jamshedpur. Right : Pipe-still tar distillation plant erected by the Chemical Engineering and Wilton's Patent Furnace Co., Ltd.

tion of aromatic compounds from open-chain raw materials in industry it is obvious that use must be made of the materials available in suitable naphtha cuts from petroleum sources, in the light oils, largely paraffinic in nature, arising from the low temperature distillation of coals and in the corresponding fractions of light spirit arising from the high pressure hydrogenation of coal or from the synthetic processes of liquid hydrocarbons starting from water gas with catalysts such as cobalt, iron and nickel." It is further pointed out that pyrolysis of acetylene and methane yields benzene; that the action of sulphuric acid on ketones yields aromatic hydrocarbons; and that ring closure may be affected by the action of metals on dihalides and in other ways. It may well be suggested that the products of which the coal tar industry has hitherto had the monopoly will before long be synthesised on a huge scale by the petroleum industry as part of its effort to utilise natural gas, especially methane, and cracking gas. The tar distillers may have to enlarge the scope of their research work considerably in order to maintain their business.

A REVIEW OF CHEMICAL ENGINEERING FOR 1939

By

WILLIAM C. PECK, M.Sc., M.I.Chem.E., A.I.C.

Mr. William C. Peck, the author of this article, was formerly Director and Chemical Engineer of Messrs. Burgoyne Burbidges and Co.,'Ltd., chemical manufacturers, London, and is now Lecturer in Chemical Engineering at Battersea Polytechnic and Managing Director of Messrs. Apex Construction Ltd., chemical engineers, London.

DEVELOPMENTS in any process receive their greatest impetus where that process is most extensively employed Hewson and Rees on February 17, 1939, in a paper "Some Contributions of Chemistry and Chemical Engineering to Steam Generation" before the Institution of Chemical Engineers, showed that this aphorism applied to large power-station practice. The introduction of pulverised fuel firing has had a profound effect upon boiler efficiency, but the authors show that the advances in the technique of burning coal on grates is less well known and certainly merit attention.

Whilst great attention has been paid to soundness of engineering design for that technique, the chemical point of view has been sadly neglected. The classical researches by Kreisinger, in U.S. Bureau of Mines Technical Paper No. 137 (1917), showed that the gases emerging from a bed of burning coal which is thicker than 4½ in. will be rich in carbon monoxide and entirely denuded of oxygen at all likely gas velocities, but advances based on these experiments were long delayed. The obvious chemical necessity for adequate control of the supply of air at all stages of the combustion process, and the fact that a chemical reaction can proceed to completion only if the reactants are brought into intimate contact, have now received some recognition. Forcible injection of secondary air into the combustion chamber at the proper places, and the provision of a large combustion chamber to allow time for the reacting gases to diffuse together, allows coal to be burnt on mechanical stokers with less than 20 per cent. excess air. Improved design of grates, and the elimination of refractories from the combustion chambers, remove restrictions formerly imposed on the fuel bed temperatures, which is now limited only by the softening temperature of the coal ash. As a result a greater proportion of the heat is transferred by radiation and less by convection in the boiler passes, so that boiler efficiencies of about 90 per cent. are now commonplace everyday practice.

Higher boiler efficiencies are favoured by the use of coal with low content of moisture, ash, hydrogen and sulphur, with a fairly high agglutinating value and a high ash fusion temperature. The paper deals with the estimation of heat losses and the problems of boiler scale, caustic embrittlement and corrosion of plates and turbine blades. The washing of

flue gases is reported on, with particular reference to development of the removal of oxides of sulphur from such gases by first washing with river water in contact with rusty steel scrubbers and finally, for the removal of last traces of sulphur oxide, by a chalk suspension in contact with wooden scrubbers.

Bearing Metals

The Copper Development Association published under the title "Lead Bronze Bearings" a translation from an original German publication by the Deutsches Kupfer Institut E.V. While the development of this type of alloy in Germany may be ascribed to the trend of substituting valuable elements, such as copper, by cheaper metals, the development of steel-backed copper-lead bearings is valuable, especially where exacting conditions of speed and load are encountered. The publication deals with the theory of bearings, and the running in, antifriction properties and load capacity of the alloys. A paper on "Recent Developments in Bearing Metals," by H. L. Evans and S. T. Harrison, given to the Chemical Engineering Group on February 3, dealt also with high-duty bearing metals for internal combustion engines where the necessity for new and better alloys is keenly felt. The three types of failure, fatigue cracking, "wiping" leading to seizure, and corrosion, were considered. Although the ideal bearing metal is still a thing of the future, very rapid advances have been made. The low melting points of tin and lead base alloys and possibly cadmium seem to limit their application, and whilst this does not apply to copper-lead and silver, these latter materials have peculiar problems of their own. With copper-lead bearings the optimum lead distribution has not been attained and improvements in manufacture are required. Powder metallurgy offers a promising way out of the difficulty and encouraging results have been obtained by drawing lead under vacuo into copper sponge.

The maximum working temperature of steam and chemical plant was, until comparatively recently, within the range of temperatures at which the properties of the constructional materials were not divergent from those at ordinary temperature. During the past 20 years, however, there has been a distinct trend towards the use of much higher temperatures with industrial plants, and these higher temperatures have been accompanied by increased working pressures and rates of heat transfer. Under these conditions the properties of the materials of construction do not correspond with those disclosed by the ordinary tensile test procedure. Fracture can be caused by a stress much less than that required to produce failure of a tensile test specimen when pulled at the normal rate, if the stress is applied for sufficient time. The phenomenon is known as "creep"; and it has been widely investigated during the past 20 years. The greater part of the investigations have been concerned with the determination of the creep properties of steels at elevated temperatures. A paper by J. McKeown, before the Chemical Engineering Group on January 9, dealt with creep in non-ferrous metals, which has not received so much attention. The influence of various factors affecting creep resistance is discussed. Temperature, of course, is the most important factor, but very small differences in chemical composition may produce very large differences in creep resistance, and variations in methods of production may profoundly affect this property. The creep properties of lead and lead alloys, tin and tin alloys, aluminium and aluminium alloys, copper and bronze and other copper alloys, and nickel alloys are summarised in the paper, which has a comprehensive bibliography.

The use of higher pressures in industry found expression in two complementary papers before the Institution of Chemical Engineers in 1939. The first paper, by R. L. Quertier, given on March 14, dealt with the "Problems of Compressors and Compressed Gases in Industry." This was a valuable exposition of modern gas-compressor practice and dealt comprehensively with all the types of air and gas compressors, vacuum pumps and exhausters used, together with the design of accessories. Problems in the design of compressors and vacuum pumps with a view to increased efficiency were discussed, and the trend of development with this class of machine towards increased rotational speeds and increased piston speed, as a result of which there is much less chance of saving any appreciable power during compression by means of the cylinder cooling provided. The tendency is to increase the number of stages and cool the gas between the stages by means of inter-coolers. The various methods of testing air compressors are described, and a complete test code will shortly be available from the British Standards Institution. The paper includes descriptions of the uses of compressed air in the chemical industry, particularly for the mixing of slurries.

The second paper, given by Professor D. M. Newitt, before the Institution on December 12, admirably supplemented the previous paper by a treatment of the theoretical aspects of compressor practice, with special reference to their bearing upon the design of compressors and circulating pumps for high pressures. The most convenient procedure in dealing with problems involving the handling of gases is to equate the total energy entering and leaving some suitable section of the system under consideration, according to the method first employed by Bernouilli. The formulae usually employed are based on the behaviour of an ideal gas, and Professor Newitt shows that the changes in pressure, as a result of the work done on or by the gas whilst it is traversing the section, have to be taken into consideration. The PV relationships generally used imply that the internal energy E and the enthalpy H are independent of volume, and hence the two specific heats of the gas are each independent of pressure and temperature. These assumptions are incorrect, but in certain circumstances, low and medium pressures, they do not introduce any serious error into the calculations. When the pressure range may be up to 1,000 atmospheres then variations in the specific heats are appreciable. When calculating the work of compression and taking into account these variations, Professor Newitt shows that the most convenient method is to construct an enthalpy-temperature-entropy (H-T-S) chart for the gas and evaluate the work terms by graphical methods. Sufficient detail is given to indicate clearly the method of carrying out the fundamental calculations involved in the design of high-pressure compressors.

The Institution of Mechanical Engineers circulated a paper by Lake & Inglis on "The Design and Manufacture of Bursting Discs." The demand for a reliable device which, when fitted to a vessel, will burst before the pressure reaches a dangerous value is more evident when the working pressures for chemical plant are being raised. Three types of bursting discs, the plain diaphragm type, the cross-cut diaphragm type, and the shear type, are described and the principles of their design given.

"Floors for Industrial Purposes" was the title of a paper by Fitzmaurice and Lea of the Building Research Station before the Institution of Structural Engineers and the Institution of Chemical Engineers on January 26. The authors confined themselves to the standard flooring materials, wood, rubber, concrete, etc., but did not deal with proprietary flooring, though these are much used. The paper dealt with the problems of resistance to impact, abrasion, and chemical attack and included recommendations for suitable floor surfaces for a number of different types of processes. A paper by Stratton and Hough on Factory Floors, published in *Industrial and Engineering Chemistry* (*31*, 3, p. 283) gives characteristics of floor surfaces.

Heat Transfer

A paper on Boiling Film Heat Transfer Coefficients in a Long Tube Vertical Evaporator, by Stroebe, Baker and Badger, continues the work of Badger on Heat Transfer in Evaporators. Published in *Industrial and Engineering Chemistry*, 1939 (*31*, 2, 200), this is the first systematic work on liquid film coefficients in a long tube vertical evaporator, in which boiling occurs over the whole length of the tube. Data on film coefficients to boiling liquids in vertical tubes are limited Badger and co-workers derived an empirical

correlation of the coefficients obtained with several liquids, expressing the coefficients in terms of the Prandtl number, surface tension of the liquid, specific volume of the vapour, and average temperature drop across the liquid film, all based on the average boiling liquid temperature. A relationship between the average liquid temperature and the vapour temperature was also derived, from which the average liquid temperature can be predicted from variables known to the commercial designer.

Heat Transfer Coefficients and Liquid Velocity in a Basket Type Evaporator are the subject of a paper by Front, Baker and Badger which also appeared in *Industrial and Engineering Chemistry* (*31*, 2, 206). A formula was arrived at for predicting the coefficient for known boiling point, temperature drop and liquid level conditions, but no quantitative expression for the difference between the vapour temperature and the average liquid temperature was obtained, though this appears to be of the order of about 1°F. The necessity of predicting the average liquid temperature, because of its influence on the true temperature difference for evaporator design purposes, and also because it is of importance when designing evaporators for use with heat-sensitive materials, is thus becoming apparent.

Industrial Wastes

A valuable group of papers was presented before the Division of Industrial and Engineering Chemistry of the American Chemical Society in Boston. They are reported in *Industrial and Engineering Chemistry* (*31*, 11, 1311-1380) and deal with wastes, including atmospheric pollution by gases and fine particles, from many industries, including the pulp and paper, textile, tanning, steel and nonferrous metals, petroleum, rubber, and food-stuffs industries.

Civic pride, economics and business hound waste with only the single aim of change and prevention, until a compromise is effected that satisfies nobody. A more sympathetic treat ment of waste is needed. The industrialist slowly but surely is recognising that waste treatment and disposal is a necessary manufacturing cost. When attacked from this point of view, the process of waste treatment can, more often than is suspected, be made to yield profit. As examples can be cited the manufacture of sulphuric acid from smelter gases, furfural from oat husks, vanillin from sulphite waste liquors, and copperas from waste pickle liquor.

A series of papers on Fluid Flow appeared in *Industrial and Engineering Chemistry* (*31*, 4, 407-482). The chemical engineer is interested in fluid dynamics for many reasons. In the first place he is concerned in the friction losses that result from fluid flow under a wide variety of conditions, such as flow of a liquid in pipe lines, flow of liquid through packed solids, two-phase flow as a gas and a liquid or a gas and a finely-divided solid. On the other hand, fluid dynamic effects are of fundamental importance because of their influence on the rate of heat transfer and of mass transfer in fluid streams. The papers presented cover the theorectical considerations as well as the engineering problems concerned with the design and selection of pumps, which are the practical agents of the fundamental principles of fluid dynamics and fluid flow.

E. S. Byng, in a paper read on April 18 to the Institution of Chemical Engineers, dealt with the "Administrative Training of a Chemical Engineer." The need for training to fit a chemical engineer for administration has always been recognised by the Institution, and Mr. Byng's paper emphasised that modern industry requires men who combine technical skill with administrative knowledge. One of the tasks in this country was to make the industrialist "chemical-engineer-conscious," for in both the education and utilisation of the chemical engineer this country was still behind the United States.

The general recognition of the chemical engineer as a professional man experienced in the design, construction and operation of plant and works in which matter undergoes a change of state and composition, occurred during the last war and the Chemical Engineering Group and the Institution of Chemical Engineers were formed during or just after that period. The organisation of the people for war emergency during the spring of 1939 therefore would seem to have been more easily accomplished than during the last war. The establishment of the Central Register of the National Service Department of he Ministry of Labour, however, as far as the enrolment of the chemical engineer was concerned, was not without misunderstanding on the part of certain committees set up under the advisory body, the Central Register Advisory Council. In September, 1938, when the Central Register was planned, the problem of classification arose and chemical engineering was classified as a specialised branch of engineering similar to the mechanical, electrical, gas, marine, and other branches. The distinction of the chemical engineer from the chemist was apparent and this has always been recognised in American and Continental technical spheres. By such a classification only could the services of the chemical engineers in this country be utilised to the best advantage in a national emergency. It was with considerable surprise to find that early this year the Central Register Advisory Council had adopted a new classification and that Chemists and Chemical Engineers in industry were found in one broad group. The Institution of Chemical Engineers was not satisfied that this later classification for enrolment was in the best national interest, and subsequently a modification of the classification was made and a separate class for chemical engineers adopted.

Dr. Levinstein in a letter to *The Times* of May 23 disagreed with the revised schedule of reserved occupations whereby chemical engineers of 21 are reserved along with chemists of the same age. He pointed out the inconsistency of the classification and also to the admission age of 25 to the Institution of the Chemical Engineers. Drawing upon his extensive experience in the last war, he stated that when the chemical industry has to be expanded suddenly, the greatest shortage of man power will be found in the lack of charge hands and experienced foremen. As subsequent experience has shown, there is a great demand in certain branches for men not necessarily possessing the technical qualifications which would enable them to become corporate members of professional institutions, but who through long experience in industry would be qualified to take up certain supervisory posts as assistant works managers and the like.

British Exports for 1940

A Contribution Towards Victory

MR. GUY LOCOCK, C.M.G., Director of the Federation of British Industries, has issued an encouraging New Year message to traders in this country. British industry, he says, can face 1940 in good heart. Its response to the call of war has amply demonstrated its adaptability and resource. Immediately before the war, trade reached a high level of activity, and, despite the inevitable difficulties following on the transition from peace to war-time organisation, the export situation is improving.

The great task before us is twofold: first, the supplying of the needs of civil defence and the fighting forces, and, second, the maintenance, as far as possible, of our home and overseas trade. The vigorous functioning of the export trade is vital. Service orders must, of course, take priority, but nobody doubts the significance of the economic weapon by which Germany's previous markets can be won and our own existing markets held.

To fulfil this task, manufacturers must be able to rely on a continuous flow of the necessary raw materials, and on the provision of plant and man-power and reasonably stable prices. In this field, I am sure, we can look forward to Government direction and help. Industry is fully alert to the significance of exports, and I have every confidence that, with wise generalship, we shall in 1940 advance in that field and thus contribute to the coming victory.

NEWS EVENTS OF 1939

January

The 29th annual exhibition of scientific instruments and apparatus, organised by the Physical Society, was held at the Imperial College of Science and Technology, South Kensington, London, S.W.7. Eighty-four firms exhibited in the trade section and there were 27 contributors to the research and educational section.

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Mr. Emile Mond, chairman of the South Staffordshire Mond Gas Co. and the Power-Gas Corporation, Ltd., and hon. treasurer of the Chemical Society and the Faraday Society, died, aged 73.

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Sir Frank E. Smith relinquished his appointment as secretary to the Committee of the Privy Council for Scientific and Industrial Research and was succeeded by Professor E. V. Appleton.

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Dr. Henry Dreyfus, chairman and joint managing director of British Celanese, Ltd., received the Perkin Medal of the Society of Dyers and Colourists in Bradford.

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Occupations in the chemical and allied industries were listed in the Government's Schedule of Reserved Occupations.

February

New extensions to the works of Boots Pure Drug Co., Ltd., were put into operation in the Midlands.

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The resignation of Dr. H. J. T. Ellingham from the hon. secretaryship of the Chemical Society was announced.

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Professor Arthur Smithells, Emeritus Professor of Chemistry at Leeds University and former director of the Salters' Institute of Industrial Chemistry, died, aged 78.

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New laboratories of the British Pottery Research Association were opened at Penkhull, Stoke-on-Trent, by Lord Falmouth.

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Mr. F. Heron Rogers was elected president of the Institution of Chemical Engineers at the annual meeting. "My Fifty Years in the Explosives Industry" was the title of an address delivered by the retiring president, Dr. William Cullen.

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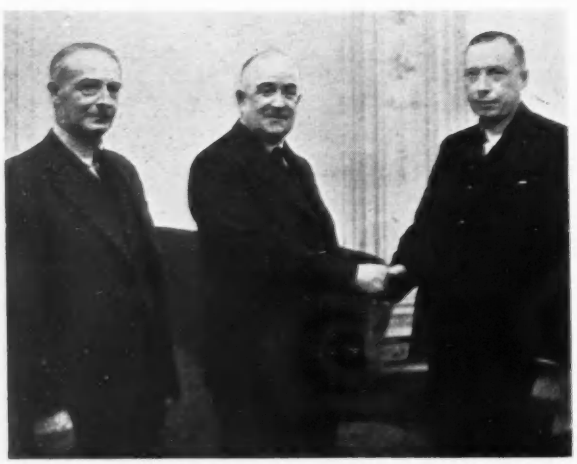

Mr. J. Baddiley (right) photographed after receiving the Perkin Medal from Mr. F. F. Flinn, president of the Society of Dyers and Colourists.

The Perkin Medal was awarded to Mr. James Baddiley, of Imperial Chemical Industries, Ltd., by the Society of Dyers and Colourists "in recognition of his national services for the renaissance of the British dyestuffs industry through many important investigations in the field of colour chemistry conducted or directed by him."

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The British Industries Fair, 1939, opened at Olympia and Earls Court, London, and at Castle Bromwich, Birmingham. The Chemical Section at Olympia was again under the auspices of the Association of British Chemical Manufacturers.

March

The annual report of the Institute of Chemistry, adopted at the sixty-first annual meeting, revealed that the membership consisted of over 7,200 qualified chemists. Mr. W. A. S. Calder was elected president of the Institute in succession to Sir Robert Pickard.

Mr. W. A. S. Calder.

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Professor W. H. Roberts was elected president of the Society of Public Analysts and Other Analytical Chemists.

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Mr. Robert W. Paul was awarded the sixteenth Duddell Medal of the Physical Society.

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The 21st annual dinner of the Oil and Colour Chemists' Association was held at the Park Lane Hotel, London. The president, Mr. A. J. Gibson, was in the chair.

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Dr. C. H. Desch was re-elected president of the Institute of Metals at the 31st annual meeting. The outstanding event of the year according to the annual report of the Council of the Institute was the removal of the headquarters of the Institute to No. 4, Grosvenor Gardens, which made possible the scheme of further co-operation with the Iron and Steel Institute

April

The Rutherford Memorial Lecture was delivered by Sir Henry T. Tizard at the Royal Institution during the anniversary meetings of the Chemical Society.

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The anniversary dinner of the Chemical Society was held at Grosvenor House, London, with Professor F. G. Donnan, president, in the chair. The toast of the Chemical Society was proposed by Lord Samuel.

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Mr. Peter F. Bennett was re-elected president of the Federation of British Industries.

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Dr. T. Moran, principal scientific officer at the Low Temperature Research Station, Cambridge, was appointed director of research of the Research Association of British Flour Millers.

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To celebrate the 21st anniversary of the five-day week introduced by Benn Brothers, Ltd., proprietors of THE CHEMICAL AGE, a luncheon was given by the directors.

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At the annual meeting of the British Chemical Plant Manufacturers' Association Mr. J. W. Wright was elected chairman.

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Mr. Victor Blagden was re-elected president of the British Chemical and Dyestuffs Traders' Association, Ltd.

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The annual dinner of the British Chemical Plant Manufacturers' Association was held at the Trocadero Restaurant, London. An address on "The Training for Management of Chemical Engineering Works" was given by Mr. H. Ward.

May

Lord Eustace Percy was elected president of the Royal Institution at the anniversary meeting of members.

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Mr. Geoffrey Lloyd, Secretary for Mines, inspecting the new plant for refining oil obtained from the low temperature carbonisation of coal.

A new plant for refining oil obtained from the low temperature carbonisation of coal was opened by Mr. Geoffrey Lloyd, Secretary for Mines. The refinery is operated by the British Diesel Oil and Petrol Co., Ltd.

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Professor W. L. Bragg was elected president of the Institute of Physics.

June

Mr. Horace Boot was appointed president of the National Federation of Clay Industries.

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Professor J. F. Thorpe.

Mr. W. J. Courtauld was made a baronet in the Birthday Honours List. New knights bachelor included Mr. A. C Maclean, founder of the firm of Macleans, Ltd., manufacturing chemists, Mr. W. Fraser, deputy chairman of the Anglo-Iranan Oil Co., Ltd., and Professor J. F. Thorpe, Emeritus Professor of Organic Chemistry at London University.

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It was announced at the annual meeting of the Institution of Gas Engineers that it was proposed to establish a Gas Research Board which would, in future, be responsible for co-operative research in the gas industry.

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References to the steady progress made by the Copper Development Association and to the satisfactory position in which it had become established as a central bureau of information for the copper industry were made at the annual meeting of the Association by Mr. D. Owen Evans, M.P., chairman of the Council.

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Professor J. W. Cook, Professor of Chemistry at London University, was appointed Regius Professor of Chemistry at Glasgow University.

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The value of standardisation in industry was emphasised by Mr. R. S. Hudson, Secretary to the Department of Overseas Trade, when proposing the toast of the British Standards Institution at the annual luncheon of the Institution at the Dorchester Hotel, W.1.

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Lt.-Col. J. H. M. Greenly agreed to continue as president of the Institute of Fuel for another year.

New buildings of the Department of Glass Technology at Sheffield University were opened by Lord Riverdale, chairman of the Advisory Council for Scientific and Industrial Research.

July

Some 1,500 technical representatives from all parts of Great Britain met at Teddington to review the work of the National Physical Laboratory on the occasion of the annual inspection of the Laboratory by the General Board.

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New laboratories of the British Non-Ferrous Metals Research Association were officially opened by Mr. Oliver Stanley, President of the Board of Trade.

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The 58th annual meeting of the Society of Chemical Industry was held at Exeter and was attended by more than three hundred members and guests. On the evening of the opening day there was a reception by the president, Mr. Victor G. Bartram, and by the deputy-president, Viscount Leverhulme. The annual meeting was held at the Washington-Singer Laboratories, University College of the South-West. Professor J. C. Philip was elected president in succession to Mr. Bartram.

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Dr. R. D. Haworth was appointed to the Chair of Chemistry at Sheffield University in succession to Professor R. P. Linstead.

August

A vigorous defence of large scale industrial units was made by Lord McGowan, chairman of Imperial Chemical Industries, Ltd., in an article dealing with "Industry's Need To-day."

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It was announced that Sir Andrew Rae Duncan was joining the board of Imperial Chemical Industries, Ltd.

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The U.S. Department of the Interior announced the discovery of a new mineral, officially named "shortite."

September

Following the outbreak of war a number of emergency regulations were put into operation, including the prohibition of certain imports and exports.

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Various organisations associated with the chemical industry announced emergency measures, including changes of address.

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The remaining meetings of the British Association for the Advancement of Science at Dundee were cancelled.

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The control of supplies and prices of molasses and industrial alcohol was undertaken by the Minister of Supply. Other commodities were subsequently similarly controlled.

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The first war-time list of reserved occupations was announced by the Ministry of Labour. The schedule included various occupations affecting the chemical and allied industries.

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According to the sixty-third annual report of H.M. Inspectors' of Explosives the number of accidents in manufacture during 1938 was about the same as for the previous year, but the number of casualties was higher.

October

Maximum prices for certain mercury compounds were fixed by a new defence regulation. Dealings in molasses, industrial alcohol and acetate were subjected to similar restrictions.

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The Melchett Lecture for 1939 was presented to members of the Institute of Fuel by Mr. H. A. Humphrey. His subject was "The Supply of Explosives during the War and the Early History of Billingham."

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Sir William Jackson Pope, Professor of Chemistry in the University of Cambridge since 1908, died.

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The 23rd annual meeting of the Association of British Chemical Manufacturers was held in London under the chairmanship of Mr. E. V. Evans. It was stated that during the past year the Association had done a large amount of work on behalf of and in conjunction with the Government in preparing for the war. Mr. E. Wallace was elected president of the Association and Mr. R. Duncalfe chairman of the Council.

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The Council of the Chemical Society formed an Advisory Research Council, the main function of which would be, when approached, to bring to the notice of Fellows and others engaged in chemical research subjects for investigations likely to be of potential value to the nation at the present time. Sir Robert Robinson was appointed chairman of the Council.

November

Professor R. V. Wheeler, Professor of Fuel Technology at Sheffield University since 1921, died at Sheffield, aged 56.

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It was announced in the House of Commons that a Government committee had designed a gas producer specially suitable for the conversion of motor vehicles in an emergency.

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Mr. Arthur Russell was elected president of the Mineralogical Society for 1940.

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An order was made by the Ministry of Supply taking control of all toluene, toluol, and all other coal tar spirits containing more than two per cent. of toluene.

December

At the annual meeting of the British Association of Chemists Professor F. G. Donnan was elected president for the ensuing year in succession to Dr. J. Vargas Eyre. Several members deprecated a tendency among young chemists to under-rate the commercial value of their abilities when applying for positions.

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A scheme for the co-ordination of science in war-time was discussed at the annual council meeting of the Association of Scientific Workers. After lengthy discussion it was decided that the Association should not press for a Ministry of Science.

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Mr. K. M. Chance was re-elected president of the Institute of the Plastics Industry.

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Members of the South Wales section of the Institute of Chemistry celebrated the 21st anniversary of the establishment of the section. Many well-known chemists attended the coming-of-age celebrations, including Mr. W. A. S. Calder, president of the Institute.

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The 1939 Nobel Prize for Chemistry was divided between Professor A. Butenandt, director of the Kaiser-Wilhelm Institute for Biochemistry, Berlin, and Professor L. Ruzicka, the University of Technology, Zurich.

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Sir William Bragg was re-elected president of the Royal Society at the anniversary meeting at Cambridge.

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Several firms of interest to the chemical industry were among those added to the schedule of concerns affected by the Trading with the Enemy Order.

THE PLASTICS INDUSTRY IN 1939

By

HARRY BARRON, Ph.D., B.Sc., A.I.C., A.I.R.I.

Dr. Harry Barron, at 32, is already one of the leading authorities on Plastics and Rubber in Great Britain. He is author of "Modern Rubber Chemistry," and has had numerous articles published on these subjects. He is at present Plastics Engineer with Pirelli-General Cable-Works, Ltd., a branch of General Electric Co., Ltd.

Dr. Harry Barron.

EACH year brings to the Plastics Industry a quota of new materials, novel processes, improved equipment, and a host of attractive articles. The seeds sown in previous years sprout and sometimes come to fruition. The germ of an idea, haltingly expressed in some academic paper, suddenly emerges as a practicable and even a commercial reality. The process, which a short year ago was awkward and expensive, undergoes a transformation; modified and "streamlined," it performs its function with an ease that is almost ridiculous. There are indications of materials which will in due course mature into major plastics. Some developments are inconvenient. No sooner does one find a plastic that performs a difficult task extremely well, than another with even better performance appears on the scene. There is, of course, the other side of the picture. The mortality is high. Many ideas of brilliant promise fade into oblivion.

The past year was no exception in these respects. There were many indications of materials that will inevitably become important. Until the appearance of war clouds on the horizon, the year showed promise of being a vintage year for plastics. All the major plastics countries have had to trim their sails to the winds of war. The outbreak of war has almost blacked out our knowledge of developments in the very prolific field of plastic discovery in Germany—where plastics are regarded as a major industry. The United States alone can pursue the free and untrammelled creative urge as it applies to plastics. She has the field to herself—untouched by the grim necessities and restrictions of warfare.

First to dispose of the few available statistics—as usual from United States sources. Although it was not true either of Great Britain or Germany, the plastics industry in the United States had suffered in 1938 the first recession in its history. The spread of plastics products in other industries had become so wide that a general depression made itself felt even in the plastics industry. Coal tar resins, which are mainly the phenol-formaldehyde group, dropped 25 per cent. to 107 million lb. in 1938. On the other hand, other synthetic resins were up by 23 per cent. to 23 million lb. Urea resins were up to 9 million lb. Nitrocellulose plastics were down by no less than 50 per cent. to 9½ million lb., while at 14 million lb. cellulose acetate production was considerably lower than in the previous year. It is almost certain that the figures for 1939 will show a resumption of the upward trend, since plastics business that had improved during the year showed indications of a boom after the outbreak of war in Europe. For reasons that will become apparent it is unlikely that the cellulose plastics recovered to their former levels. In this country it is almost certain that we have maintained the high levels attained in every type of plastic other than the polyvinyl family. It is likewise certain that the use of plastics has mounted in Germany, by sheer necessity if for no other reason.

The Thermosetting Plastics

Phenolic resins still surprise us with further spectacular developments, nowadays more frequently from the processing angle. The injection moulding of thermosetting resins definitely arrived during the year as a commercial process. This makes available a fully automatic moulding method, shortens the curing cycle, and increases the output. The ease and speed of production are comparable with the injection moulding of cellulose acetate powders. The process has excited particular interest among the American car manufacturers, especially Ford and Chrysler. The use of phenolic resins as bonding agents for the production of laminated materials has expanded in every direction. The great progress suggests the impending consummation of one of the fondest hopes of all plastics engineers, namely, the use of plastics for structural purposes. These laminated structures, whether based on wood, fabric, or paper, are increasingly applied for functional structures and mechanical purposes. In particular, much has been heard about the increasing use of laminated plastics in aircraft construction. The moulding of laminated plastics is already well advanced. Great interest has been aroused in the prospect of aircraft constructed mainly of moulded plastics. This automatically implies the impending arrival of mass-produced aircraft. Although greatest activity has been evident in the United States, other countries are undoubtedly interested. One American company has produced aircraft in which the entire fuselage is moulded from laminated wood, bonded and impregnated with phenolic resin. For these and for wings, the presses and moulds required must be enormous, comparable with rubber flooring presses. Apart from this, however, the great expansion in the use of laminated materials for a wide variety of purposes such as interior decoration, furniture, display and so on (apart from industrial uses such as machine parts for engineering) must be regarded as an outstanding achievement of 1939.

Use of Waste Products

The production of large sheets from agricultural wastes is another important activity that showed great progress. In the United States several processes have been developed for the utilisation of waste wood and sawdust, which by direct chemical treatment yield mouldable products. These lignin plastics are also being made from the pulp liquor wastes in paper manufacture.

In the realm of cast resins there is progress to report. During the year rapid-setting casting resins have been developed. These are fluid resins which when poured into a mould set within 24 hours on standing at ordinary temperatures. This is a great step forward. It offers scope for a much wider use of cast resins, making their use less dependent on subsequent fabrication. It obviously facilitates the application of advanced design, and places such products on a commercial basis. Many of the advances outlined for the thermosetting resins naturally also apply to the urea type, or aminoresins. In this class new types have been discovered on a basis of melamine.

There have been several notable features in the field of cellulose plastics. Cellulose acetate is unchallenged as the

leading material for injection moulding. A modified type which is competitive has appeared in the form of cellulose acetobutyrate, claiming to be more flexible and to have better water resistance. So far as the process of injection moulding is concerned, the size of mouldings that can be made grows steadily. One type of machine actually claims to be able to make an article weighing 36 ounces at one shot!

Interest in the cellulose ethers has revived. Ethyl cellulose, in particular, aroused interest for mouldings, for lacquers and for electrical purposes. There does not appear to be any serious production of either ethyl or benzyl cellulose in this country.

As is well known, cellulose acetate ousted nitrocellulose as the interlayer in safety glass. In fact until last year, in the United States, it accounted for 80 per cent. of the safety glass market. It must now in its turn give way to an even better material. One of the highlights of 1939 was the development of polyvinyl acetal plastic as interlayer for safety glass. A large proportion of American car manufacturers are known to have used it, and it is suggested that during 1939 it may have secured as much as 50 per cent. of the market. This probably accounts for the setback in cellulose acetate consumption already mentioned.

Triumph of Joint Research

Polyvinyl acetal is one of the greatest achievements of a joint research effort. It was created by the pooled resources of five leading American chemical firms, who are said to have spent no less than £1,250,000 on the work. Its impact resistance is twice as great as that of cellulose acetate at ordinary temperatures, and at low temperatures it is five times as great. It is remarkably tough, has a high yield value, and is very flexible. It is easy to handle and, being resistant to moisture, it requires no edge sealing. It allows the use of thinner glass.

Last year will also stand out for the arrival of Nylon, the new fibre, based on a new synthetic resin. This is essentially a thermoplastic material of very high softening point, the resin being obtained by the condensation of pentamethylene diamine and sebacic acid. The fundamental raw materials are coal and lime. Nylon is an extraordinary example of a material which was produced virtually to specification. The late Carothers—surely one of the greatest of plastics chemists (he was already famous for his part in creating Neoprene)—formulated theoretically the probable composition and structure of the material which would have the desired properties, and then proceeded to synthesise it. Nylon fibres already are taking the place of bristle. The finer threads threaten to supersede not only pure silk, to which it is mechanically far superior, but also rayon. From our viewpoint there was some satisfaction in the knowledge that it will be made in this country by a new concern jointly owned by Courtaulds, Ltd. and Imperial Chemical Industries, Ltd. In the same field and of great importance was the appearance of another type of fibre made from polyvinyl chloride, and known as Vinyon.

Casein Plastics

The production of fibres is probably the only distinct indication of progress in the class of casein plastics. Despite the misgivings and pessimism regarding the Lanital casein fibres developed by Ferretti in Italy, they appear to be progressing. The European output in 1939 was estimated to be the very substantial amount of about 4,000 tons. During last year there has been much activity in this direction in the United States with processes evolved by Whittier and Gould.

I must qualify my comment on casein plastics by reference to activities which might be regarded as in the class of phenolic resins. Ford has achieved notable success in the production of moulded plastics derived from soya beans, which contain a large proportion of casein. One cannot help being impressed by the recurring evidence of the use of agricultural products for making plastics. Ford has created a vast new agricultural crop for the United States, and has harnessed it to industry, plastics being one of the most happy results. In this connection it is interesting to note that during the year high claims were made for plastics obtained from the surplus coffee of Brazil.

Britain Behindhand in Vinyl Plastics

The most prolific section of the plastics industry is that based upon vinyl derivatives. There have been numerous developments during the past year, but so far as we are concerned it is a very gloomy picture, as we trail far behind the United States and Germany in this section. I attribute this very largely to the fact that we have no carbide industry in this country. Without it we are entirely dependent upon outside sources of supply, inevitably stifling any possibility of initiative. As the importance of polyvinyl plastics becomes increasingly more noticeable in our own major industries the folly of not possessing a carbide industry becomes more and more apparent. To date the most important polyvinyl plastic has been the chloride and its copolymers. During 1939 proprietary materials such as Koroseal, Mipolam, and Vinylite made great progress in their applications. It is a well known secret that an English type may shortly be available; the sooner the better.

Advances in the process of copolymerisation are outstanding. The scope made available by this technique is unlimited, and activity is ceaseless. Materials which alone appear to offer little promise, are transformed into magnificent commercial materials by copolymerisation with a small proportion of some other material. The best known example is the material formed by copolymerisation of polyvinyl chloride and polyvinyl acetate, to yield the above-mentioned proprietary products. The patent position shows the enthusiastic zeal with which the Germans have applied themselves to this. The Americans, too, have not been slow to utilise the technique. Unfortunately we have little material to work it on.

A sidelight on this question is cast by the next point. Undoubtedly one of the outstanding features of the year was the completion of the huge plant at Schkopau in Germany, for the production of Buna synthetic rubber. The primary object is not of great interest from the purely plastics point of view. What is important is the fact that enormous plants were erected for making the necessary intermediates, namely, butadiene from acetylene, via carbide obtained from coal and lime; the other important one being polystyrene. Both are made on an unprecedented scale. The numerous processes involved in making butadiene from acetylene all yield large quantities of intermediate vinyl derivatives as by-products. These are nearly all capable of polymerisation and copolymerisation. Thus whatever the value assigned to the production of Buna as against rubber, there can be no doubt as to its influence on the plastics industry. Obviously this is an objective picture, and the current war situation completely alters the perspective. It is some consolation to realise that during 1939 the production of polystyrene in this country by the Distillers Co., Ltd., gained impetus and is now well established. This plastic is very important to electrical work.

The brightest spot in British plastics achievements has been the arrival of Polythene as a commercial material. Particularly valuable for electrical work, Polythene, which is polymerised ethylene made by Imperial Chemicals, Ltd., is a major contribution to the plastics industry.

Petroleum as a Source of Plastics

It has been of great interest during the past year to watch the mounting importance of petroleum as a source of plastics. New techniques of thermal cracking and novel catalytic processes are revolutionising this aspect of chemistry. By far the most important plastic yet prepared from petroleum via iso-butane is polyisobutylene. During the past year its use acquired a firm footing in this country. Fortunately, although German sources of supply are now closed, it is still available from the United States. In an article during the year (THE CHEMICAL AGE, *41*, 1,044, 5-6) I emphasised its growing application. I would also mention the imminent production of glycerine from petroleum, a fact of no little importance to

the plastics industry. Other newly developed catalytic processes may also have profound influence on plastics production.

This review would not be complete without some reference to the influence on the industry of the World's Fair at New York. The use of plastics there far transcended anything that had previously occurred. Every important plastic in commercial production was to be found. The application of plastics for display purposes overshadowed all other media. The cream of the designers in the United States showed the world what they could do, an example that we might well emulate. The co-operation between art and industry, in sculpture, in decoration, as well as in manufacture, was miles ahead of anything that has previously been evident.

War and Plastics

Before concluding, it is absolutely essential to consider the influence of the war upon the plastics industry. This is the first time it has had to face war conditions in this country. What part does it play in the wartime economy? If not a major industry from the point of view of capital invested, yet plastics are undoubtedly of major importance. In one way or another plastics have penetrated into most industries, frequently for uses which current requirements render fundamental. The industry is bound to be tremendously busy. I need not dwell upon the obvious requirements for the Services and the Government. Apart from these, the removal of metals from free circulation, accompanied by restrictions on their use, has opened up a field for plastics in which normally they could not compete. Germany has been eliminated as a supplier of moulded goods, and raw materials such as celluloid. This was a very large business, carried on at prices far too low for our manufacturers to compete against.

This brings us to the position of raw materials. There seems to be no likelihood of shortage of phenol or cresylic acid. These are derived from coal tar. Also synthetic plant is available for the production of phenol. Formaldehyde, too, is now produced synthetically, and there should be little anxiety on this score. Auxiliary materials are abundant, although the cost of the major filler, wood-flour, may rise appreciably owing to shipping difficulties. The materials for the synthetic production of urea, ammonia and carbon dioxide are at hand, and its production should be stimulated. There seems no reason for any concern regarding the production of cellulose plastics, adequate supplies of raw materials for the actual plastics and their plasticisers being available.

The position may become somewhat difficult in the very important field of synthetic resins employed for coatings. For example while phthalic anhydride will be obtainable by oxidation of naphthalene derived from coal tar, there is no certainty regarding the availability of glycerine. As for oil-modified resins, there is almost certain to be shortage of tung oil, the substitution of which will be by no means an easy task.

RECENT PROGRESS IN SOLVENTS AND PLASTICISERS

By

ERIC H. BRITTAIN, B.Sc.

Mr. Eric Brittain has for some years been responsible for the collection and interpretation of information relating to solvents and allied subjects for the Research Department of the Distillers Company, Ltd., and its associated companies, including British Industrial Solvents, Ltd.

IN a year of unprecedented international stress, culminating in open hostilities, the whole organic chemical industry has been making a widespread search for new raw materials. Products which have previously run to waste are being carefully examined and worked up into valuable materials. This applies to the common solvents, especially to the aliphatic alcohols. In the U.S.A., for example, the recently-published statistics of the year ending June 30, 1939, show that the total production of ethyl alcohol remained at the same figure as for the previous year, but there has been a significant increase of about 30 per cent. in the ethyl alcohol made by a synthetic process at the expense of the well established fermentation process.

In Italy, where the sugar beet has been the main source of alcohol for some time past, the sugars of the sweet millet and those obtained by the hydrolysis of wood cellulose are now used extensively. Surplus wine is also being distilled to increase alcohol production. Sweet millet is also being used in the French Colonies as a source of alcohol, whilst maize is being developed as another raw material for the same purpose. Even the tops of the sugar cane are being used in India, in addition to molasses, as a source of fermentable carbohydrate.

Numerous new denaturants for ethyl alcohol to be used for solvent purposes have been suggested. These include dibenzylamine, diphenyl ether, dichlorethyl ether, formamide, isobenzonitrile and a product, known as caoutchoucine, obtained from distilled rubber. It has been reported that the sandalwood oil obtained by extracting the wood with ethyl alcohol is superior in quality to that obtained by the usual pressing process.

The search for raw materials as an alternative to maize for the production of butyl alcohol and acetone has shown that whey can be fermented after treatment with protein precipitants. A yield of 18 kg. of mixed solvents per cubic metre of whey has been obtained by this process. A variety of artichoke known as Helianthus, which contains sugars in addition to inulin, is also now being used extensively as a source of solvents, whilst cassava or manioc is being employed in Japan.

Methanol from Coal

The manufacture of methanol by a synthetic process is based on coal as the raw material, and it is the expensive high-pressure plant necessary for the synthesis rather than the raw material that limits the output. The erection of another synthetic methanol plant in this country is, however, being actively considered at the present time. The purification of synthetic methanol is often a troublesome procedure, as distillation alone does not always give a clean product suitable for solvent purposes. A recent patent discloses that the addition of chromic acid prior to distillation effectively eliminates impurities.

The production of isopropyl alcohol from propylene in Russia has apparently been causing some difficulties, judging from the literature on the subject. Hydrocarbons are first removed by treating the alcohol with a salt solution, whilst tertiary butanol is eliminated by means of sulphuric acid and aluminium sulphate. The product is then dried by distillation with benzol and the dried alcohol carefully fractionated to separate off the higher alcohols. The presence of nearly all these impurities could be avoided by carefully purifying the propylene used as raw material. Work has also been going on in Russia in an attempt to obtain higher alcohols by a modification of the synthetic methanol process. It was found that the highest yields, consisting of about 5

per cent. of higher alcohols and 75 per cent. of methanol, were obtained using a catalyst containing zinc oxide, alumina and vanadium pentoxide.

Octyl alcohol has long been known to be a useful anti-foaming agent and it has recently been found that its value for this purpose is very much enhanced by the addition of paraffin oil. Several other alcohols are now available commercially in the U.S.A., and these form an interesting range of high-boiling alcohols for use in lacquers and synthetic resin varnishes. Included among these are *n*-hexanol, 2-ethyl butanol and methyl amyl carbinol. The last-named is said to be useful for securing good flow, high gloss and blush-resistance in lacquers, and is the first heptyl alcohol to be made on a commercial scale.

The Glycols

So far as the glycols are concerned, ethylene glycol is by far the most important of this series; the established process of directly hydrolysing chlorhydrins to the glycols is being largely superseded by a two-stage process. In this, ethylene chlorhydrin, for example, is first converted into ethylene oxide by treatment with strong alkalies and the ethylene oxide combined with water to give ethylene glycol. This method avoids recovery of glycol from aqueous salt solutions, which is a very troublesome procedure. Ethylene glycol is now being used as the liquid conductor in electrolytic condensers. Diethylene glycol, on account of its hygroscopic nature, is frequently used in the textile trade as a lubricant, and to soften fibres and increase their flexibility. The question of the toxicity of the glycols has often arisen, and very careful examination of a number of glycols and glycol ethers has been made, showing that all these substances are more or less toxic, although propylene glycol can be tolerated in small quantities.[1] The glycol ethers are very valuable solvents which have been known for many years and ethylene glycol mono-ethyl ether has been used in lacquers for cars for some time. Recent new uses for this substance include the drying of natural gas before it is pumped through pipe lines under high pressure and for the extraction of resins, etc., from wood. A comparison of the properties of the mono-ethyl and mono-propyl ethers of ethylene glycol[2] has revealed that the latter has distinct advantages over the former. The propyl ether is less volatile and is a better solvent for oils and oil-soluble resins. It has a considerably greater dilution ratio for petroleum-type diluents and its solutions flow better and show less tendency to give rise to blushing. The acetate of the propyl ether shows correspondingly improved properties when compared with the acetate of the ethyl ether.

The lower aliphatic ethers are very valuable solvents; their tendency to form unstable peroxides has somewhat militated against their use in industry. A recent American patent states that both ethyl ether and di-isopropyl ether can be stabilised by means of monobenzyl para-aminophenol. Propylene oxide has been found to be a useful solvent for fumigants as it is not so volatile as ethylene oxide and is, therefore, easier to transport. The production of dioxane from glycol has been found to proceed more satisfactorily if *p*-toluene sulphonic acid is used in place of ferric sulphate as dehydrating catalyst.

Research Among the Esters

In the field of esters, the most important class of compound used in both solvents and plasticisers, there is little to report about new methods of manufacture. Attempts are still being made to produce esters directly from alcohol by passage over a suitable catalyst. In one of the methods published recently, ethyl alcohol is passed over a catalyst consisting of copper hydroxide activated by uranium and aluminium oxides. The yield is poor, however, and the number of esters than can be produced in this way is limited.

A very useful investigation of the solvent strengths of the lower esters[3] has been made by the constant viscosity procedure. This has demonstrated that *n*-butyl acetate and isobutyl acetate possess the same solvent powers for nitrocellulose with toluene as diluent. Ethyl propionate has been shown to be an excellent solvent, occupying an intermediate position between ethyl acetate and butyl acetate.

An investigation of the resistance of ethyl lactate to hydrolysis by water has shown that this ester is considerably more stable than has hitherto been supposed and, with small quantities of water present, the hydrolysis is practically negligible. A number of new esters is now available in the U.S.A. These include the acetates and borates of the alcohols, sorbitol, and mannitol, which are obtained by the reduction of sugars. Butyl mesityl oxide oxalate (which has recently been placed on the market) possesses strong insect-repelling properties and solutions of derris root in it are being offered as liquid insecticide sprays.

There has been a great deal of investigation into the physiological effects of solvents and plasticisers, which has disclosed that the vapours of some of the widely used solvents are even more toxic than was previously known. It has been frequently emphasised that it is of the utmost importance to educate workers in the dangers of handling volatile solvents. A rather unusual case of poisoning was described recently, when an epidemic of toxic polyneuritis in South Africa was traced to the contamination of cooking oil by tricresyl phosphate. A very interesting report of investigations of the National Bureau of Standards in Washington on the possibility of developing a non-inflammable dope for aircraft based on cellulose derivatives other than nitrocellulose has recently been published.

Plasticisers for Polystyrene

It has been suggested that the aryl phosphates are the most suitable plasticisers for cellulose acetate lacquers for aeroplanes, as they are non-inflammable and do not crystallise out of the film even at high concentrations. Esters of silicic acid have been suggested as plasticisers for cellulose acetate and lacquers so formulated give films which adhere strongly to glass without deterioration. A considerable amount of investigation has been directed towards plasticisers for the polyvinyl resins, particularly polystyrene, the polyvinyl acetals and the acrylic resins, all of which are rapidly coming to the fore in the plastics industry. Esters of sebacic acid have been found to be suitable for use with polyvinyl acetal resins in the production of laminated glass. The acetals of thiodiglycol have also been suggested for this purpose.

The polymerisation products of α-methyl styrene are now available as plasticisers for polystyrene, whilst the alkyl esters of maleic, succinic and citric acids have also been referred to as plasticisers for polyvinyl resin. Esters of keto-alcohols such as diacetone acetate have been mentioned as plasticisers for cellulose acetate. A useful method of obtaining a homogeneous dispersion of plasticiser in a cellulose ester has been described. This is carried out by mixing the two materials at a temperature below that at which the plasticiser exercises a solvent action, but which is above the melting point of the plasticiser, and finally heating the whole to the temperature at which the plasticiser acts as a solvent.

Since the outbreak of war the purchase and use of most of the solvents in other than small amounts has come under the control of the Ministry of Supply, and Orders have been issued by the Controller of Molasses and Industrial Alcohol, who is responsible for the supply of these materials.

[1] Laug, Calvery, Morris and Woodard—J. Ind. Hyg. and Tox., May, 1939.
[2] Paint Technology 1939, **4**, 21.
[3] Ware and Teeters—Ind. Eng. Chem. 1939, **31**, 1118.

STOCKHOLMS SUPERFOSFAT FABRIKS A.B. is building a new factory for the manufacture of calcium cyanamide at Stokvik near Sundsvall, Sweden. This extension will make possible a considerable increase in production. For the purpose of financing this new extension the company proposes increasing its capital stock from 9,000,000 to 12,000,000 crowns. The new shares, having a nominal value of 150 crowns, would be offered at par, which means that the old stockholders would have a rather valuable subscription privilege.

NEW CHEMICAL PLANT IN 1939

Continued Enterprise of British Firms

AMONG the interesting advances in the construction of chemical plant during the year 1939, MESSRS. KESTNER EVAPORATOR AND ENGINEERING CO., LTD., report that they have been exceptionally busy with drying and evaporating plants and two interesting developments have been made and tried out with great success, the first in connection with the now well-known Kestner patent spray drying plant and the second in connection with the Kestner multi-stage high vacuum patent evaporator. The use of spray drying plants for the production of powdered products in one operation from solutions and solids in suspension is now well known, but most of the spray drying plants used for industrial purposes are relatively large machines handling big quantities. It has been felt for some time that there would be great advantages in a small-scale spray drying plant if it could be made compact and simple to operate. Following experimental work, Kestner's have now perfected an apparatus of this kind and a number of these plants have been sold and put into successful operation during the year. An important feature is the elimination of all external separators, cyclones and bag dust collectors. The plant comprises a cylindrical drying chamber with a new patented internal filter system. Each plant is supplied complete with an air-heater and a draughting fan.

The Kestner multi-stage high vacuum evaporator has been used for a number of years for concentrating sensitive products such as milk, edible gelatin, etc. An entire new process has been patented whereby fruit juices can be concentrated in these evaporators, at the same time retaining volatile esters and flavouring bodies contained in the fruit.

A plant now under construction for a well-known firm who heat-treat oils and varnishes illustrates the value of fluid heat transmission. It is provided with circulation of Perolene at temperatures up to 350° C. and in the same plants by means of changeover valves Perolene is circulated through a cooler to bring down the temperature of the system rapidly when the cooking is finished.

The outstanding feature of the year's activities of MESSRS. GEORGE SCOTT AND SON (LONDON), LTD., has been the marked development of high vacuum distillation for such products as glycerine, glycols, fatty acids, ethanolamine, resins, etc. These plants operate at from 1 to 3 mm. absolute. A number of glycerine distillation plants have been furnished for use at home and abroad, from which it is possible to obtain chemically pure glycerine in one distillation. In all cases distillation is effected without the introduction of open or carrier steam, representing a marked economy in fuel consumption and permitting of close fractionation of the distillate.

Several interesting evaporating plants have likewise been supplied, including a new design on thermo-compression lines. The plant concerned, which is constructed in its contact surfaces in stainless steel throughout, embodies thermo-compression with the Scott patent forced circulation device. Easy access to the impellor is a valuable feature, introduced where cleansing and sterilisation are of vital importance.

The well-known balances manufactured by MESSRS. L. OERTLING, LTD., are, and always have been, of entirely British manufacture. During the Great War the firm were virtually the only British manufacturers of first-rate precision balances, and now war has come again, and the resources of the company are devoted to supplying the laboratories of the Empire and those of friendly countries. Undoubtedly the most important development in analytical technique during recent years has been the development of micro-analysis. Particular attention is therefore directed to the Oertling micro and semi-micro balances, which have been applied with the greatest success by the leading exponents of this technique. In the matter of balances used for chemical analysis, and also those used for assaying, it is not always appreciated what great strides have been made in the design of instruments for rapid and accurate work. Such instruments are aperiodic, the swing of the beam being damped by an air or magnetic break. In addition, the rapid and accurate reading of the balance is facilitated by such developments as the Oertling prismatic-reflecting device and the Oertling "Multiweight" device. By such means the use of loose weights below one gram can be avoided and direct readings obtained to the nearest 1/10 mg. (1/100 mg. by estimation) in as little as 30 seconds.

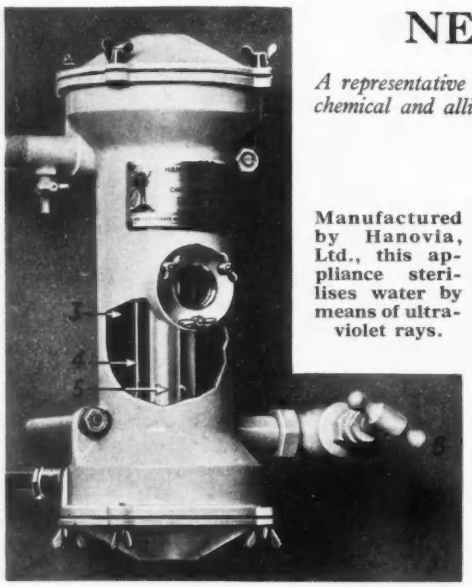
During the past year MESSRS. W. J. FRASER AND CO., LTD., have continued to supply large-scale stainless steel process plant—including several vacuum evaporators, both of the forced circulation and natural circulation type; and also gum and synthetic resin kettles. Particular attention has been paid to the development of continuous processes operating under high vacuum down to, say, 0.5 mm.

There has been a growing interest in "Dowtherm," of which Frasers are the sole British suppliers. Dowtherm is a high-boiling-point organic compound used in the vapour phase for economical heating over the difficult temperature range 210°-400° C. Being a condensing vapour, Dowtherm secures a high rate of heat transfer. The temperature control is very accurate and pressures are low. For instance, a pressure of 50 lb. per square inch gives a temperature of 340° C. In order to demonstrate in a practical manner the advantages of this vapour-phase system which, to use the words of a well-known chemical engineer, "acts so surprisingly like steam," Frasers have installed a demonstration plant at their works. Continuous and discontinuous distillation and evaporation can be carried out in this plant under high vacua and high temperature conditions.

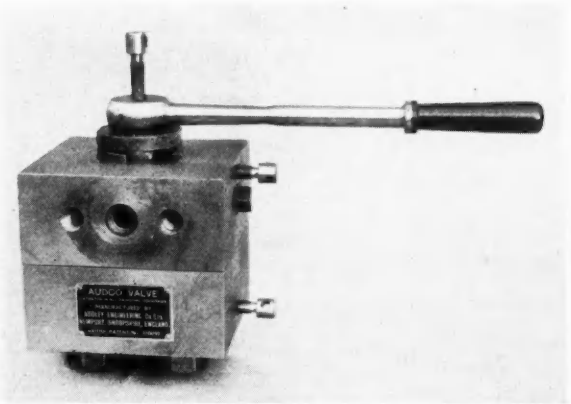
An interesting feature reported by MESSRS. METROPOLITAN-VICKERS ELECTRICAL CO., LTD., was the development of a technique for processing woven glass fabrics, and the subsequent adaptation of the finished product to the needs of the motor designer requiring an insulating material conforming fully to the British Standards Specification for Class "D" insulating materials. When glass fabrics are used for insulation, they are invariably treated with a varnish to fill the interstices of the weave, so that the utmost advantage can be taken of the high dielectric strength and resistance to abrasion inherent in this material. After considerable research a varnish has been developed which fulfils these requirements and, more important, maintains its properties at temperatures in excess of those which may reasonably be expected in the windings of motors working on severe duty cycles. Processes for applying this varnish have been perfected, and exhaustive tests have proved that glass fabrics so treated do not deteriorate with age. The greatest field of application for glass insulated motors is undoubtedly to be found in situations where operating conditions are particularly severe, and where reliability is of paramount importance. In conformity with this policy, the company has during the last twelve months been in a position to offer glass insulation on any of the range of Metrovick motors and generators. One noteworthy order executed early in the year, comprised five 200 h.p. 3,300 volt type "MF" flameproof slipring induction motors for use in an oil refinery abroad, where an unusually high ambient temperature is recorded at certain times of the year. Motors may be supplied with vitreous insulation throughout, or alternatively, specially treated asbestos and mica may be used in conjunction with glass tapes, cloths and sleevings.

NEW APPARATUS IN 1939

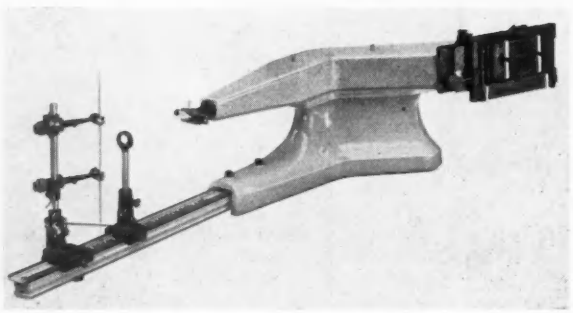
A representative selection of the new apparatus placed on the market in 1939 by firms in the chemical and allied industries is illustrated below. They range from a generating set to the latest example of water sterilisers.



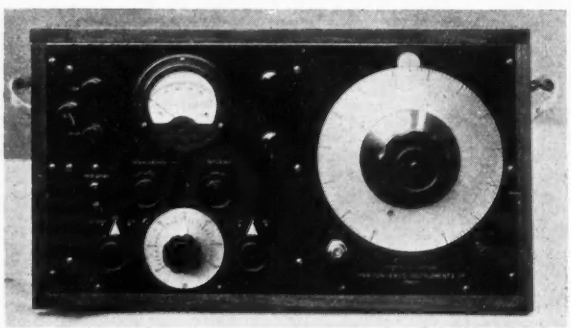
Manufactured by Hanovia, Ltd., this appliance sterilises water by means of ultra-violet rays.



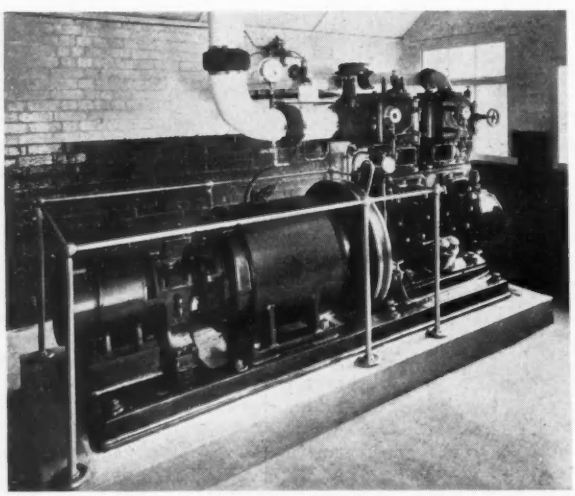
An Audco high-pressure disc valve exhibited at the British Industries Fair by the Audley Engineering Co., Ltd.



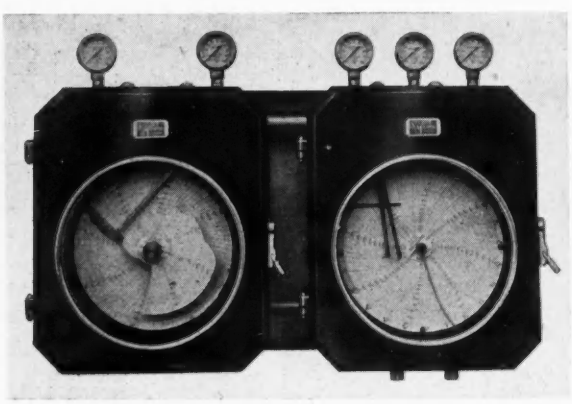
A recent example of a medium quartz spectrograph manufactured by Adam Hilger, Ltd.



A new *p*H meter introduced by Marconi-Ekco Instruments, Ltd.

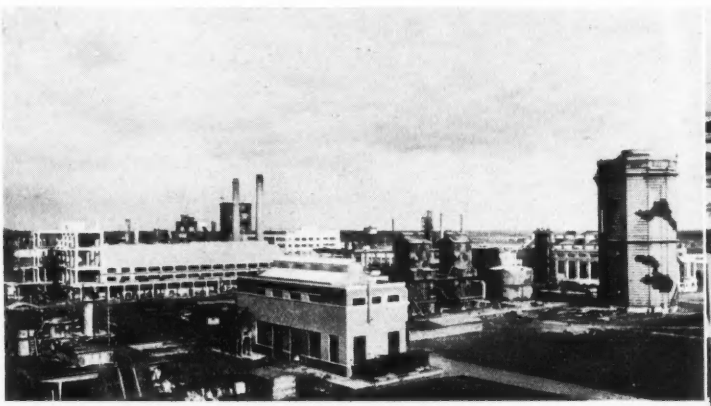


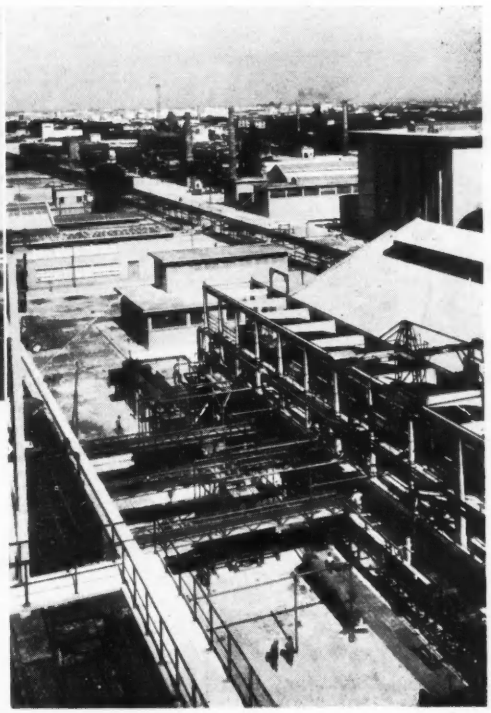
A generating set running in parallel with a grid supplied by Ashworth & Parker, Ltd.

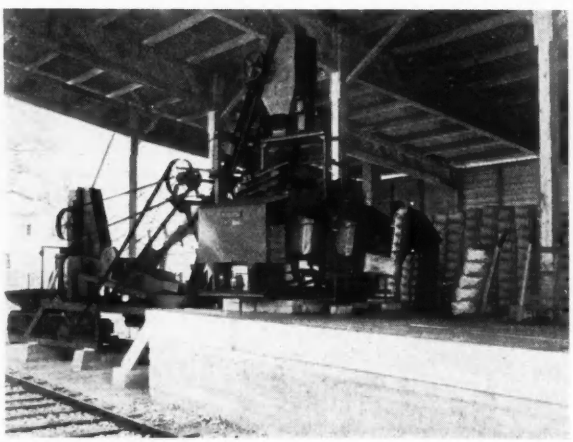


A new version of the well-known time schedule controller made by Short & Mason, Ltd.

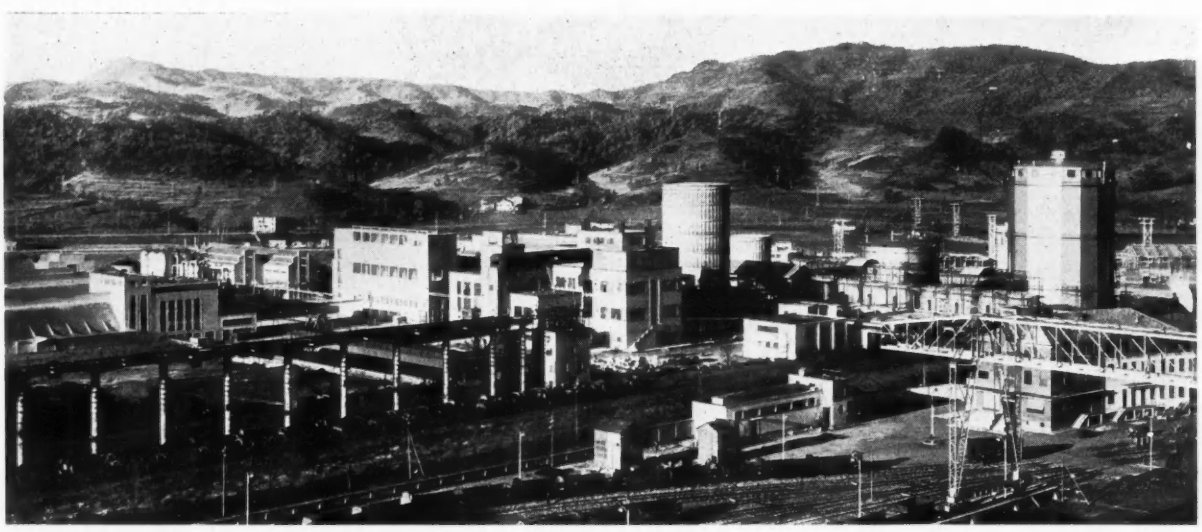
CHEMICAL DEVELOPMENTS ABROAD







Chemical development abroad during 1939 *was particularly pronounced in Italy. The illustrations above are of two hydrogenation plants completed by the Azienda Nazionale Idrogenazione Combustibili at Leghorn and Bari. Below is a general view of a new plant for the synthetic production of nitrogen compounds opened by the Montecatini concern at San Giuseppe di Cairo, near Savona, Italy. A new system, evolved in France, for the packing of chemical products in paper bags of the valve type is illustrated on the left by a "Gravitas" filler installed in a fertiliser plant.*



THE CHEMICAL INDUSTRY IN FRANCE

A Satisfactory Position

From a Special Correspondent

THE main chemical industry in France and the branches of industry connected with it are in quite a satisfactory state to-day. The first weeks of the war brought difficulties, chiefly in the supply of indispensable workers, but by now this difficulty has been completely overcome. The supply of chemical products for war purposes is quite adequate, as businesses are working at an intensive rate towards this end, while civil requirements, now much diminished, can be met by means of a few adjustments, rationalisation being more and more in evidence. The main chemical industry is well provided with orders. In perfume and soap production, however, work has diminished, the possibility of export being reduced. The colour and varnish industry is accumulating stocks as the building industry has been inactive since the war began and is likely to remain so throughout it. The demand for fertilisers for next spring is assured, while in the petrol industry next year's production depends upon the supply of raw materials; in this respect France and England, as is well known, are working together.

Since the beginning of the war chemical industry has been obliged to make new sacrifices, employers and employees alike. The profits of the industry are severely limited by State measures; as to the workers, their working day has been prolonged, and a new tax of 15 per cent. for normal hours, and of 40 per cent. for overtime affects their wages. The transition from peace-time to war-time has actually caused no change in the chemical industry. Even before the war the State intervened in this industry, the system then being known as "directed" economy. The difference between past and present consists in the fact that to-day we follow a plan aiming at a final uniform result, an aim that was lacking in peace-time. At the same time the State wishes to safeguard the liberty of economic life. That is why it assigns an important place to independent organisations in the domain of supply of raw materials as well as in that of centralisation of orders, of transporting factories, etc. The employers' federations work under the surveillance of the authorities, but as the industry does not desire to deviate from the principle of private initiative, its independent organisations are to be continued. During the world war good results were obtained by giving freedom to chemical production. The authorities favour the formation of groups of small and medium-sized businesses, not only to facilitate the partition of the largest orders among several undertakings, but also to ensure the continued activity of businesses whose managers have been mobilised. The creation of special technical bureaux, which play a useful and much appreciated part in the sharing-out of Army orders among small and medium-sized businesses, can be considered as the result of corporate action. Collaboration with the workers is earnestly desired throughout the industry. The period of acute social tension and struggle is over, and a tendency towards co-operative effort between employers and employees is evident.

Supply and Price of Raw Materials

The supply of raw materials for chemical industry has so far been effected without difficulty. But this question is inextricably bound up with the question of price. The prices of industrial products are subject to strict control by mixed committees or by the State authorities themselves. It is hoped to stabilise prices, as far as possible, as has been done with wages, which are fixed at the level of September 3. In the chemical industry the stabilisation of prices is of great importance, for the State does not wish to pay more when new orders are given. Moreover, the State wishes to keep wages at their present level, at all costs, and this is only possible if prices are likewise maintained at their present level. On account of the State's strong position, as the biggest customer, the Government can adjust the level of prices, even where direct State intervention is impossible.

Compensation Boards

At present there is a firm tendency in all French markets of chemical goods. The authorised increases in prices of chemical products shows that the State, in spite of its desire to maintain a rigid price control, thinks also of maintaining profits. In future, also, price control will no doubt be applied in such a way as to ensure the continued prosperity of the industry.. In certain branches of industry compensation boards have been set up, as was the case in 1914-18. These boards aim at removing the taxes on the cheaper national raw materials so as to be able to compensate the importers of foreign raw materials. It is hoped thus to avoid excessive increases in the price of imported raw materials. It is not yet known whether these boards will be set up in the chemical industry, but it is likely. Each board is supervised by the particular organisation in charge of supplying the country with war essentials. So far, iron ore and manganese, all metals, coal and liquid fuel have been subjected to the regulation of these boards.

Export Problems

The question of export has been particularly difficult since the beginning of hostilities. In this case, also, adaptation to new circumstances is taking place. Commercial negotiations with several countries are in progress at the moment, mainly on the basis of the purchase by France of chemical raw materials, and of her selling manufactured products. Negotiations of this kind are in progress with Spain, Yugoslavia, Belgium and Switzerland. But principally it is a quêstion of trade relations with the United Kingdom. The industry would like British importers to restrict their foreign buying, as far as possible, to purchases from France. It considers that it can deliver several categories of goods which England bought, before the war, in Central Europe. The branch of industry particularly adapted to export to the U.K is the perfume and soap industry. French luxury articles, it is believed, would not compete with British goods; it is also to be noted that France has always admitted English luxury soaps and other articles of the kind.

Among the numerous enactments made since the beginning of war, the following are important to the chemical industry. The formation of new industrial or commercial enterprises is forbidden. During the last war the establishment of numerous new businesses contributed to an increase in the price of goods; moreover, new enterprises prevented the resumption of activity of businesses existing before 1914 but closed on account of the war. The law aims at preventing these two inconveniences. War insurance, with State participation, introduced by law, corresponds to the analogous English law, except that there is no compulsory insurance against war risks, this insurance being optional and limited to categories of goods determined by the State.

The first four months of the war, with their relative calm, the opposite of what was expected, have caused a feeling of assurance and optimism. In the sphere of industrial chemistry we are convinced that not only will the Allies win the war, but that precautions have been taken to ensure the regular working of the national economy, even in the event of the ultimate course of the war being quite different from at present. Thus, in the event of a violent collision between the main armies, the supply of France and her colonies with both raw materials and manufactured goods, and the production of both military and civil essentials would encounter no difficulty that could not be quickly overcome.

General News——From Week to Week

NELSON CORPORATION Gas Department is installing a benzol recovery plant at its Brierfield works.

WALSALL GAS DEPARTMENT is to instal a new benzol and toluol recovery plant at its Pleck works.

SCOTTISH DYES, LTD., are to erect a chemical manufacturing shed and a drying shed at their factory in Earl's Road, Grangemouth, at a cost of £30,000.

AN INCREASE of ¾d. an hour; or 6d. each shift to all male gas workers of 18 and over, has been decided upon by the National Joint Council for the Gas Industry.

THE LONDON SCHOOL OF HYGIENE has investigated, with very satisfactory results, the use of ammonium chloro-acetate for the destruction of the potato eelworm larva.

FROM DECEMBER 27, 1939, the address of the British Leather Manufacturers' Research Association, formerly at 18-20, St. Thomas Street, London, S.E.1, will be: 1-6, Nelson Square, London, S.E.1. (Telephone, WATerloo 4432).

A FIRE occurred last week at the chemical works of Pancreol, Ltd., Marfleet Avenue, Hull. A brick building containing hundreds of gallons of inflammable spirits was involved. The roof was blown off and flames rose to a great height. The building and contents were destroyed.

ARRANGEMENTS HAVE BEEN MADE for the January meeting of the Pharmaceutical Society of Great Britain to take place in the Society's House on January 9 at 7.30 p.m., when Mr. A. D. Powell, A.I.C., will deliver the Harrison Memorial Lecture, on "Drug Standards: Their Development and Application." Mr. Powell was awarded the Harrison Lectureship Medal in 1939 and this occasion is being taken to present the medal to him.

OWING TO THE DEARER market for raw materials, Messrs. May & Baker, Ltd., announce the following price increases: Sodium and Potassium Tartrate B.P. (Rochelle Salts) to 85s.-90s. per cwt., according to quantity (up 5s. per cwt.); Seidlitz Powder B.P. to 68s.-71s. 9d. per cwt. (up 3s. 9d. per cwt.); Double Seidlitz B.P.C. to 75s. 3d.-79s. 6d. per cwt. (up 4s.-4s. 3d. per cwt.). The previous market alteration was on July 16, 1937.

THE MANCHESTER SECTION of the B.A.C. is holding its usual winter functions in spite of emergency conditions. A conversazione will be held on Saturday, January 6, at the Engineers' Club, Albert Square, Manchester, from 6 to 10.30 p.m. A discussion has been arranged at the Engineers' Club on February 14 at 7.15 p.m., on the subject: "Is not present university education too academic to meet the needs of would-be industrial chemists?" This will be opened by Mr. W. A. Silvester and supported by Mr. F. Scholefield.

PLUMBAGO CRUCIBLES ARE AFFECTED by a recent Board of Trade Order amending the schedule to the Export of Goods (Prohibition) (No. 2) Order, 1939. Previously plumbago crucibles were prohibited to be exported from the United Kingdom to any port or destination outside the United Kingdom. The amendment confines the prohibition to any port or destination "in any country or State of which any part is in Europe or on the Mediterranean or Black Seas," or to any port or destination "in any insular territory or dependency of such country or state situated in the Atlantic Ocean north of Latitude 10° N. and east of Longitude 35° W. not being a port or destination in France or any French colony or protectorate or in Egypt or Palestine."

AT THE THIRD annual general meeing of shareholders of Calthrops, Limited, cattle food manufacturers, Liverpool, Mr. D. B. Roberts, who presided, mentioned that the decline of the net profit of £34,967 by £8,401 was accounted for by difficulties of trading in many other trades besides their own. Up to the present the cause of the explosion of September 21 had not been ascertained, but it had been established that it took place in a vertical elevator, and not in any of the silos. Owing to the present difficulties in the building trade, the rebuilding of the property damaged by the ensuing fire would take a considerable time, but the firm had used temporary measures to such advantage that within six weeks after the fire they were daily manufacturing a quantity of feeding stuffs equal to more than half normal. They were hopeful of reaching almost normal capacity by March next.

THE FOURTH MEETING this session of the Society of Chemical Industry (London Section) will be held in the rooms of the Chemical Society, Burlington House, Piccadilly, W.1, on Monday, January 8, at 2 p.m. The chairman, Dr. T. H. Durrans, will preside. Dr. W. H. J. Vernon will read a paper on "Some Recent Studies of Thin Oxide Films on Metals."

THE ANNUAL REPORT of the Manchester M.O.H. (Dr. R. Veitch Clark) mentions that the department was much concerned with complaints of dust nuisances from a heap of material stored in the open by a chemical manufacturing firm. The substance was "spent oxide" consisting of oxide of iron, which had been used for gas purification, during which sulphur was absorbed.

DESPITE THE MANY war claims on its resources, the Imperial Institute, South Kensington, S.W.7, has just published the 1936-38 edition of its *Statistical Summary of the Mineral Industry of the British Empire and Foreign Countries*, a volume of exceptional value as a work of reference. In its 453 pages are given all the statistics available of the production, imports and exports of 55 minerals and metals, including those concerning selenium, tantalite, and columbite, tellurium and zirconium. The trade tables refer not only to the crude materials, but also to the chief semi-manufactures and in some cases the principal chemicals and their derivatives. At the end of the volume is a bibliography of special publications from which the data have been compiled.

Foreign News

PRESS REPORTS STATE that a new Estonian phosphate plant will be erected near a dry lake bed at Maardu, some 13 km. from Tallinn. A start is to be made almost at once with the construction of a narrow-gauge railway from Tallinn to Maardu.

THE EVACUATION of the little town of Wingen, on the Maginot Line near Strasbourg, has brought about the closing down of the Lalique glassworks, famous for the individual designs of the founder René Lalique. It is generally understood that the plant will not operate again.

ACCORDING TO PRESS REPORTS from the Netherlands East Indies adequate supplies of the dyestuffs consumed by the weaving mills are no longer available, owing to import difficulty. A conference was recently held between the Regent (native head official) of Madjalaja (near Bandoeng) and an official of the Department of Economic Affairs, when the establishment of a dyestuff exchange was considered. Most of the dyestuff consumed in the Indies has been imported from Germany and consisted primarily of aniline, ultramarine, artificial indigo and alizarine.

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The Heavy Chemical Industry, 1939

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so operated as to produce a negligible quantity of nitric acid and a considerable quantity of sulphuric acid under intensive conditions, or units contemplating the manufacture of considerable quantities of nitric acid, with lesser quantities of sulphuric acid, can be arranged. The flexibility of this process must make it attractive under war conditions. Fig. 3 shows the distributor arrangement in connection with one of the towers of a large Kachkaroff-M.P. sulphuric acid plant.

All sulphuric acid plants, provided the Gay-Lussac towers are sufficiently large, can be used in the manufacture of limited quantities of nitric acid, as well as the primary product—sulphuric acid. The *modus operandi* is to convert to nitrogen oxides at the platinum-rhodium gauze more ammonia than is normally required for sulphuric acid production, to oxidise these in an additional suitable tower, to absorb them in relatively strong sulphuric acid at the Gay-Lussac tower, and to transfer the excess nitrose to a denitrating tower for recovery of the nitric acid. Subject to suitable modification, most sulphuric acid factories could be production units for nitric acid.

By-Product Ammonia

The International Nitrogen Cartel ceased to function as from the early part of September, and thus Great Britain now operates independently of any other European country. The Government advised farmers in September and October last to take immediate delivery of stocks of sulphate of ammonia. Whether this course was fully justified is doubted in many quarters. There was apparently no shortage of supplies, and farmers have not been able to apply to the land all the sulphate of ammonia of which they took delivery. Barns and farm buildings are not suited to the storage of sulphate of ammonia, which must inevitably become moist, and consequently "cake."

The importance of uniform crystal size is recognised by the by-product sulphate of ammonia industry. Much has already been written on this subject, and conditions for the production of crystals of satisfactory size are generally appreciated. J. Bell, in discussing this subject, stresses the importance of (a) control of the ferric iron in the saturator liquor by means of oxalic acid, and (b) maintenance of adequate contact between the crystals and the mother liquor. Improvement of colour can be effected by the addition of creosote to the saturator. Bell has described a photo-electric "whiteness" meter, and shows various physical properties of ammonium sulphate solutions in graphic form.

Sulphate of ammonia is now classified into two types, known as Grade I and Grade II. To qualify for Grade I, the salt must conform to :—

1. *Size.* No lumps greater than 4 m.m.
   Not more than 25 p.c. to be greater than 2 m.m. (8 B.S.S.)
   Not more than 40 p.c. to pass through a 30 B.S. sieve.
   Not more than 5 p.c. to pass through a 72 B.S. sieve.
2. *Colour.* There should be no marked individual colour.

The production of concentrated gas liquor continues to grow, and there is every prospect that an order will shortly be made, enforcing the recovery of by-product ammonia in utilisable form. Improvised plant of a simple type, but equipped for operation without the necessity for labour, may need to be adopted at many of the smaller and medium-sized gasworks.

The success attending the vapour phase process (B.P. 494,023) has continued unabated. By this method partial decarbonisation is effected at a selected part of the condenser by evolving gases at a pre-determined temperature, in order to remove carbon dioxide with a minimum of ammonia. Such gases pass to a scrubber, which is fed with gas liquor. Fig. 4 shows a general view of a plant erected by Messrs. Newton, Chambers and Co., Ltd., of Sheffield, dealing with 2,600 gallons of gas liquor per hour, and producing concentrated gas liquor of 22-24 per cent. ammonia by weight.

The demand for ammonium chloride, muriate of ammonia and ammonium nitrate has grown rapidly during the last few months, and new processes, particularly concerning the latter product, have been suggested.

Alkali Industry

No improvements are noted in the manufacture of soda ash by the ammonia-soda process. But it has been observed by Die Chemische Industrie that the two soda ash factories in Russia, forming part of the Beresniki Chemical Combine, and also the Donsoda Factory, have been working much below capacity. Apparently, there have been difficulties due to shortage of limestone and transport facilities. The last renovation of the plant was undertaken in 1933.

Soda ash plant of a capacity of 20,000 tons per annum was erected some years ago by the Nordsk-Hydro, to satisfy their requirements for the manufacture of nitrate of soda. Since the introduction of the base exchange process for producing sodium nitrate from sea water, however, the soda produced at the soda factory has become available for sale.

Phosphatic Fertilisers

Superphosphate manufacturers are beginning to appreciate the importance of granular products, and the tendency of the future will be to manufacture a granular calcium superphosphate, and compound fertilisers. Messrs. Fison, Packard and Prentice, Ltd., have given a distinct lead, and it is certain that their example will be followed by other manufacturers.

It would appear that the Oberphos process, designed to manufacture a granular superphosphate under autoclavic conditions, has not proved a financial success. The abandonment of this process has been rumoured for some time. Undoubtedly, the Broadfield method possesses attractive features : it is capable of economic operation, and it is not difficult to granulate the resultant superphosphate.

Whatever may be the established belief about the importance of water-solubility as the basis of sale of calcium superphosphate, it appears certain, from important work already undertaken, but not yet published, that preconceived ideas will be seriously assailed. Beyond saying this, it would be injudicious to make any further statement, although exigencies may arise out of the war which may call for discreet representations in the appropriate quarter.

Meanwhile, it should be noted that the use in New Zealand of cobaltised superphosphate has aroused widespread interest among farmers, as a means of reducing stock diseases. Another development concerns the use of active magnesium oxide—20 to 40 lb. per ton of superphosphate. This use has been recommended as a source of magnesium, apart from which it serves as a conditioning agent for superphosphate and mixed fertilisers.

Non-Fertiliser Phosphates

As regards non-fertiliser phosphates, tetra-sodium pyrophosphate has been introduced to the market for use in cleaning operations, and as an ingredient in soap. It possesses noticeably superior water-softening and emulsifying properties. First announced in 1937, its employment has extended to many factories, particularly in America, and it constitutes a new outlet for phosphoric acid. The Monsanto Chemical Co., of East St. Louis, have erected new plant for its manufacture.

THE CHEMICAL AGE wishes all readers the greatest possible prosperity in the coming year.

Metallurgical Section

July 1, 1939

Current Topics

Electrodeposition of Nickel

The use of nickel chloride as the principal ingredient of nickel plating solutions was suggested many years ago, in connection with various refining processes, and it was then established that very thick deposits could be made from chloride baths. The data so obtained, however, were not utilised or further developed at that time by the electroplating industry. It was only recently that detailed study was made of the electrodeposition of nickel coatings from chloride baths. Work which has been done since 1935 was recently summarised by W. A. Wesley and J. W. Carey in a communication to the Electrochemical Society. A very detailed account was given of experiments carried out to determine the plating range of the chloride bath, the character and properties of deposits obtained under varying conditions, and the characteristics of the plating solution. The solution selected for study was of the type $NiCl_2.6H_2O$ (300 grams per litre), H_3BO_3 (30 grams per litre), and many of the proporties of this bath and of deposits obtained from it were directly compared with a standard Watts-type sulphate bath.

As a result of the investigations undertaken it was concluded that power costs can be approximately halved by changing from sulphate to chloride baths, and that the coatings obtained from chloride baths are easier to buff. The greater smoothness of thick deposits made from chloride baths and their lower tendency to form nodules and built-up edges are also attractive advantages in the matter of electroforming and the salvaging of worn parts. In addition, the chloride bath is easy to control. The composition of the electrolyte is simple, and sound deposits are obtainable over a wide range of plating conditions, while there is also greater freedom from pitting. Deposits obtained from chloride baths are less susceptible to pitting than are those produced from sulphate solutions; under laboratory conditions, additions of an oxidising agent were required to prevent pitting only in freshly prepared baths. Higher anode and cathode efficiencies in the case of chloride baths contributed still further to the ease of operation; under all of the conditions studied the cathode efficiency was found to be higher with chloride than with sulphate baths. Another advantage of importance concerned the heat generated in the plating bath. The operation of sulphate solutions with large amounts of work at high current densities might necessitate the use of coils for cooling the bath, but in the case of chloride baths this difficulty would not be encountered until much higher current densities were reached.

The authors suggest that a further study of electrolytes containing both sulphate and chloride may disclose a particularly useful intermediate type of solution. They point out that there are certain disadvantages of the chloride bath, one of which is the greater corrosiveness of the solution, although this is not serious, due to the fact that suitable materials are now available for the construction of the electroplating equipment. In some cases the greater hardness and lower ductility of the deposits from chloride baths might be a disadvantage, although for most purposes toughness would be a favourable characteristic. There is also a minor disadvantage in the matter of cost for the bath ingredients, nickel chloride and hydrochloric acid necessary to adjust the hydrogen ion concentration being slightly more costly than the corresponding sulphates.

Magnesium Production Cheapened in Germany

The cost of producing metallic magnesium has received considerable attention in Germany during the last few years, and definite progress has been made in the matter of effecting a reduction of costs. The detailed cost data for the most recent achievements have not yet been published, but it is believed that the results of large-scale experiments have gone far beyond the promise of a mere reduction in price. Until these recent technical advances had been made the cost of producing the metal was in the neighbourhood of 1.83 RM per kilogram, 4.3 kilograms of anhydrous magnesium chloride being needed at a cost of 0.8 RM. and the remaining items being electrodes 0.05 to 0.06 RM., electrical energy 0.3 RM., labour 0.33 RM., and general maintenance of the plant and other expenses 0.35 RM. The thermal reduction of oxide to metal is considered to offer very attractive prospects with regard to costs when magnesite is used as the raw material. Technical progress, however, has been achieved in several directions, and possibilities of making reductions in cost of production are by no means exhausted. It is anticipated that costs may be still further reduced by improvements in the preparation of the anhydrous magnesium chloride as well as in the fusion-electrolytic process itself.

The German output of magnesium metal in 1938 was said to be between 12,000 and 13,000 tons, as compared with 10,000 tons in the previous year. The leading foreign buyers of the German metal were Great Britain, Italy and Czechoslovakia. The bulk of the output came from the well-known Bitterfeld plant of the I. G. Farbenindustrie. The Wintershall concern, associated with the potash industry, also engaged in production, with an output of about 1,000 tons per year at its works at Heringen. Until recently the I. G. plant utilised dolomite as raw material, and also the so-called " end lyes " of the potash industry (from the treatment of carnallite) which contain about 40 per cent. of magnesium chloride. Owing to the abundant supplies of magnesite made available by the incorporation of Austria with Germany in March, 1938, however, magnesite is now being used upon an increasing scale as raw material. The high cost of obtaining anhydrous magnesium chloride is one of the difficulties which stand

in the way of using the carnallite end lyes. The Oesterreichische Magnesit concern now has a plant at Radentheim in Austria, to increase supplies of magnesium metal. This plant is undertaking the treatment of crude magnesite from extensive deposits in Karnten, special production processes having been developed. Unlike the Bitterfeld and the Heringen plants, the new producing unit at Radentheim will carry out the reduction of magnesium oxide with coal in the electric furnace at 2,200 to 2,300° C., but initial production will only amount to about 200 tons per year.

Phase Changes in Nickel Steel

A spheroidising treatment found satisfactory for the treatment of a carbon and certain low alloy steels is discussed by I. N. Zavarine in Technical Publication 1,031 of the American Institute of Mining and Metallurgical Engineers. It consists of cycles of repeated heating to the Ac_1 temperature, followed by immediate furnace cooling to below the Ar_1 point. The spheroidisation so produced in carbon steels is accompanied by gradual softening, and while ductility rises the yield, tensile and hardness values fall with progressive treatment. The application of a parallel treatment—modified to compensate for the difference in the position of the critical points—to a medium carbon 3.5 per cent. nickel steel, however, resulted in an increase in tensile strength and hardness and a fall in ductility and impact strength. The investigation of this phenomena indicated that the hardening effect in the nickel steel was due to the formation of a solid solution at sub-critical temperatures. It was also found that the carbide in nickel steels is partially or completely dissolved at temperatures considerably below the critical point on heating. The lowest temperature at which commencement of solid solubility was observed was in the region of 600° C. for these steels. The characteristics of the solid solution formed at sub-critical temperatures vary from those of austenite; the former is not hardened by quenching to the same extent as austenite, and on cooling it does not transform into ferrite and microscopically visible carbide as does austenite.

Factors Affecting Corrosion Resistance

From experiments on austenitic nickel-chromium steels and other corrosion-resisting alloys it has been concluded that the passivity of stainless alloys is not primarily due to a protective oxide or oxygen film, but that there are factors which can be ascribed to the electron sharing of metal atoms. This concept appears to account satisfactorily for the effect—on alloy passivity—of alloy constituents such as chromium and molybdenum, and also for the influence of normal passivating agents such as nitric acid or a layer of adsorbed oxygen atoms. This theory (*Iron Age*, 1939, *143*, 42) is shown to be in agreement with the behaviour of known compositions of passive iron-chromium, iron-molybdenum, iron-nickel and iron-nickel-molybdenum alloys. It further permits an interpretation of anodic corrosion products of stainless steels as well as potential measurements in halide solutions, which can be explained only with difficulty on the basis of an oxide film theory. A further investigation of the effect of surface finish upon stainless steels in relation to their resistance to corrosive attack by various media has indicated that a distinct difference exists between the corrosion-resisting characteristics of mechanically prepared finishes on stainless steel as produced by heavy cold rolling or by polishing and buffing, the latter finish being definitely superior. Carried out under proper conditions, the greater the amount of polishing and buffing the more corrosion resistant is the surface of the steel, but the order of merit of various types of surface finish depends to some extent upon the type of corroding agent to which the steel is exposed.

Varied Finishes for Stainless Steel

The steadily increasing use of stainless steel for decorative purposes is now causing a demand for variety in surface finish. With a view to developing products which are capable of meeting the considerable potential market for coloured and decorative stainless steel a number of etching, colouring and other processes have been investigated and T. W. Lippert (*Iron Age*, 1939, *143*, 39, 79) has given a useful summary of the methods which have been suggested, making special reference to patent specifications by which certain processes are covered. Two American methods which have been recently developed are the Coloran process of the Allegheny-Ludlum Steel Corporation and the Bachite process of the Bachine Corporation. It is pointed out that the latter process is of such a nature that it can, in certain cases, enhance the chemical stability of the alloys which are treated.

Electrochemical Measurement of Corrosion

Much valuable information upon metallic corrosion has been obtained by the use of potential measurements as an indication of film breakdown or repair, although a consideration of the various types of polarisation curve theoretically possible indicates that in certain cases the time-potential curves do not give accurate data. In a recent investigation of this subject, R. H. Brown and R. B. Mears (*Trans. Faraday Soc.*, 1939, *35*, 467), discuss the character of corrosion cells from the theoretical aspect and give a detailed report of a study of 8/18 nickel-chromium steel, the corrosion of which is known to be promoted by the presence of the ferric ion in a solution. The principal effect of ferric chloride in stimulating the corrosion of this steel is the reduction in cathodic polarisation so produced. Ferric chloride, on the other hand, has relatively little effect on anodic polarisation. In solutions containing substantial amounts of ferric chloride, cathodic polarisation can be reduced to such an extent that initial breakdown of the film may occur without change in the single potential of the specimen of stainless steel. It is therefore emphasised that it is undesirable to rely upon single potential measurements for the detection of initial corrosion breakdown in cases where the polarisation characteristics of the metal and the solution are not fully understood.

Spectrochemical Analysis

An index to the literature of spectrochemical analysis has been published by the American Society for Testing Materials. This useful compilation, by W. F. Meggers and B. F. Scribner, comprises an introductory review of the development and present position of the subject, as well as a bibliography covering the period from 1920 to 1937. The references, numbering over nine hundred, are arranged in chronological order. Instead of printing abstracts of the publications to which reference is made in the bibliography, it has been found preferable to give particulars of the location of abstracts already published. A detailed subject index shows the full scope of the subject matter as distinct from the title, and this is a highly useful feature of the publication.

British Non-Ferrous Metals Research Association

New Laboratories Opened at Euston Street

NEW laboratories of the British Non-Ferrous Metals Research Association were officially opened by the Right Hon. Oliver Stanley, M.C., M.P., President of the Board of Trade, on Thursday. After the opening ceremony the premises were open for inspection.

The new laboratories, covering a site some 90 by 50 ft., are immediately adjacent to the original laboratories, and consist of semi-basement, ground, first and second floors, the main stair being carried up to provide access to the flat roof. The following are some of the interesting features of the construction. Acid-resisting red asphalt forms the floor-surface on the ground and second floors (Physics and Chemistry Laboratories), while Burma-teak blocks are laid on the first floor (Library and Administration), and granolithic cement on the semi-basement (Mechanical Testing). The extensive use of non-ferrous metals exemplifies their advantages in modern building.

The arrangement of service-pipes so essential in a laboratory building has been designed with particular regard for economy in space, clean unencumbered ceiling, wall, and floor surfaces, and accessibility. These requirements have been met by running a covered main feeder-trench 2 ft. 6 in. deep beneath the semi-basement floor, around and close to the four main walls. From this trench narrow branch-ducts are taken vertically up for the full height of the building within the external walls—two in each window-pier. These vertical ducts, from which the various rooms are fed, have removable wood covers.

Heating is by low-pressure hot water on the "Invisible Panel" system—coils of copper pipe embedded in the ceiling—thus avoiding the many disadvantages of exposed radiators and piping within the rooms.

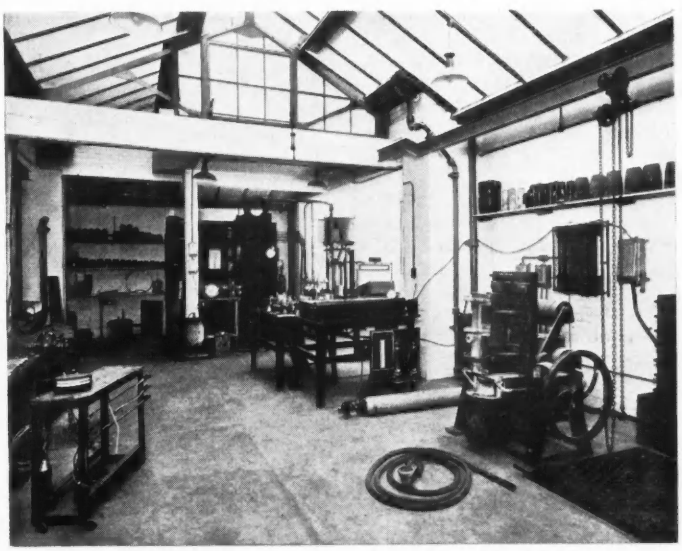
In the Melting Shop the main melting furnaces are sunk in a pit running along the north side of the shop, the tops of the furnaces being at floor level; space is available in this pit for further installations. Above the centre of the pit is an overhead runway with suitable tackle for lifting pots from the furnaces.

At the west end of the melting shop is a small high-frequency melting furnace unit, and at the east end an electric annealing-furnace having a hearth capacity of 32 in. by 20 in. Close to this the stocks of metals are kept in heavy racks.

Along the south side of the melting shop is a work-bench, one section of which serves as a moulding-bench. Moulding-sand, coke, and metal moulds are stored beneath, leaving a clear working space 11 ft. wide and 35 ft. long between the furnace-pit and the bench. Provision is made in this shop for the installation of a small drop-hammer for forging tests.

The main furnaces in the melting shop are as follows:—

(1) Natural-draught Morgan coke-fired crucible furnace. Capacity 100 lb. copper.



Part of the melting shop showing high-frequency furnace.

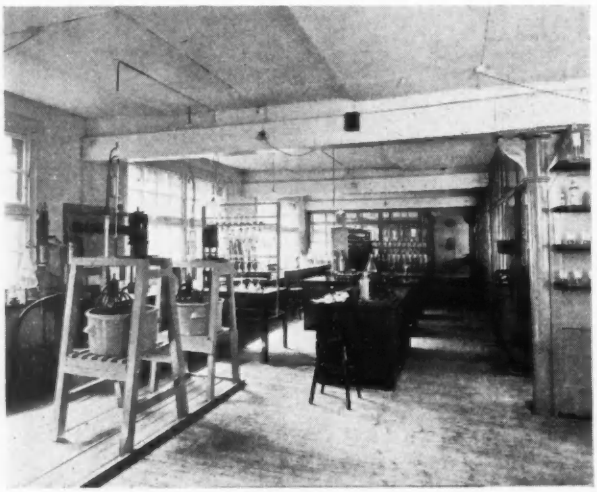
(2) 27-kVA Efco electric resistance furnace using non-metallic resistor rods (silit). Capacity 120 lb. copper. (3) Gas-fired crucible furnace, capacity 100 lb. copper, presented some years ago by the Gas Light & Coke Co. (4) 35-kVA Efco high-frequency furnace. This is of the spark-gap type and three separate furnaces are provided with maximum melting capacities of 22 lb., 11 lb., and ½ lb. copper. A fourth furnace-coil is built into a small equipment constructed in the Association's workshops for melting charges up to 2 lb. copper *in vacuo* or in controlled atmospheres. (5) 21-kVA Birlec electric resistance annealing furnace—hearth capacity 32 in. by 20 in. In addition to these larger furnaces, a number of small gas-injector and wire-bound electric furnaces are provided for small-scale working.

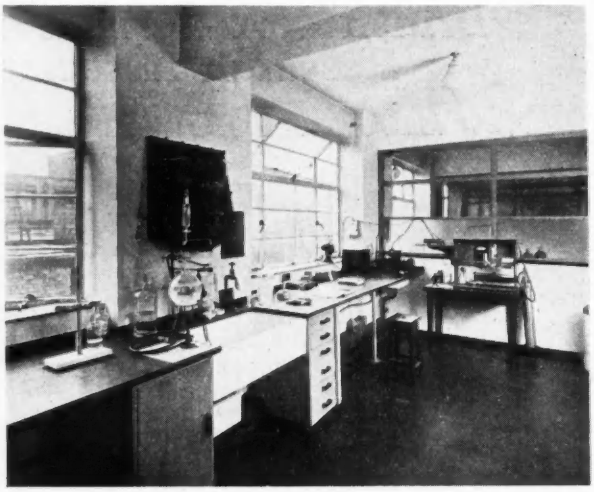
The Galvanising and Welding Shop is equipped with a fume-extraction system capable of withdrawing a volume of air per minute equal to the full capacity of the room. Here is an electrically heated experimental galvanised pot, with a capacity of just over 100 lb. of zinc. An overhead runway with a pulley block enables the full pot to be lifted from the furnace at the end of a run for pouring out the metal. Facilities for welding include equipment for gas welding, a welding-table with movable firebricks, work-bench, and vice.

The Mechanical Testing Laboratory occupies the whole of the working space (2,800 sq. ft.) in the semi-basement of the new building, one end being divided off to form a Constant-Temperature Room. This room is maintained at 68° F. (20° C.) with a control of temperature ± ½° F. The automatic temperature control operates by circulation of air at a constant temperature. The following are some of the mechanical testing machines installed in this laboratory:—

(1) *Tensile Tests.*—An Amsler 20-ton hydraulic universal testing machine, with seven ranges, from 20 to 0.2 tons; an Avery single-lever machine having a split counterpoise providing two ranges, 5 ton and 1 ton; and a small Avery lever machine which, originally a wire-tester, has been modified to carry out tests at high or low temperatures on some of the softer materials, such as lead and lead alloys.

(2) *Hardness Tests.*—A standard Vickers diamond hardness tester.





Left: Corrosion laboratory. Right: Special chemistry laboratory showing apparatus for determination of oxygen in metals.

(3) *Impact Tests.*—A standard Izod impact testing machine. This is also adapted for impact tests at high temperatures on specimens supported at both ends.

(4) *Fatigue Tests.*—A Wöhler-type machine designed and constructed in the Association's laboratories for use either with single-point or two-point loading, and having a speed of 3,000 r.p.m.; a standard Haigh-Robertson wire fatigue-testing machine with speed variation up to 15,000 r.p.m.; and a reverse bending machine (designed and constructed in the Association's laboratories), which can be used for testing sheet or pipe, either as simple cantilevers or subjected to uniform bending moment over a portion of the length.

(5) *Cupping Tests.*—A standard Erichsen machine; a Guillery machine on which three forms of cupping test can be carried out; and a machine designed and constructed in the Association's laboratories for determining the tensile strength and ductility of thin metal foils by means of fluid pressure.

(6) *Creep Tests.*—A high-temperature creep-testing unit, load 1 or 2½ tons; an apparatus for the determination of the creep resistance of lead pipes under internal pressure at elevated temperatures; six frames for creep tests under dead-loading conditions at room temperatures; a Barr & Bardgett stress-relaxation creep-testing equipment; and a machine designed and constructed in the Association's workshops for creep tests under repeated loading and unloading at room temperature.

(7) *Other Equipment.*—A hydraulic ram with variable-speed control for internal-pressure tests up to 15,000 lb./sq. in. and with a total piston displacement of 20 cu. in.; and a refrigerator for temperatures down to −40° C.

In the Physics Laboratory spectrographic analysis is carried out by means of three Hilger spectrographs, together with a non-recording microphotometer. In general physical testing, electrical resistivity measurements are made by means of a Tinsley Kelvin double bridge. An apparatus has been designed and constructed in the Association's laboratories for absolute determinations of thermal conductivity of metals and alloys by the longitudinal flow method.

A bullion balance has been adapted for the determination of specific gravities of large castings, etc. This has a capacity of from 2 to 20 kilograms and an accuracy of 1 part in 100,000. An apparatus has been designed and constructed for the quantitative measurement of specular and diffuse reflectivity.

Two rooms are available for micro-examination and metallographic preparation, respectively. A third small work-room is used for the rough cutting and filing of specimens for the Metallography and Physics Laboratories, both of which are served by an adjacent dark room.

The preparation room has standard equipment for the polishing and etching of micro-specimens. The microscope room contains two Watson bench metallurgical microscopes and a low-power Watson stereoscopic binocular microscope used for the study of coarse structures, fractures, and other specimens where great depth of focus is desirable. Photographic work is carried out on a large Vickers projection microscope with which magnifications from 3 to 2,500 diameters can be obtained.

In addition to the facilities provided in the melting shop for the heat treatment of larger specimens, a special laboratory is equipped for the heat treatment of smaller specimens and for the standardisation of thermocouples by means of a standard Tinsley thermo-electric potentiometer.

The furnaces for general use include a resistance-furnace with non-metallic resistance-rods for high temperatures, a thermostatically controlled wire-wound furnace, and two thermostatically controlled electric ovens for temperatures up to 350° C. and 150° C., respectively. A considerable number of small furnaces are in use for experimental work on oxidation and scaling tests in special atmospheres.

The Chemistry Laboratories are devoted to the analytical work required in connection with the Association's research and development work and to the working out of special methods of analysis. They comprise a main laboratory with standard and special equipment carefully designed for the purposes in view and four adjacent smaller rooms.

The main laboratory is fitted with a fume cupboard containing electric and gas-heated hot plates, and with central and side work-benches. The central benches are supplied with high pressure water for filter pumps, and are equipped with everything necessary for vacuum filtrations. The side benches are largely devoted to titration work, a good north light being available. The smaller rooms are devoted to weighings, electrolytic and calorimetric estimations, and operations requiring comparative freedom from acid and ammoniacal fumes.

The main corrosion laboratory contains a jet-test apparatus for investigation of the resistance of condenser tube materials to attack by rapidly moving aerated sea-water; a special still for producing particularly pure distilled water; two glass degreasing units designed on the Soxhlet principle; thermostats for conducting corrosion experiments at controlled temperatures; glass circulators for studying the resistance of galvanised hot-water tanks to corrosion; and electrolytic stripping apparatus (Britton's test) for measuring the weight, thickness, and structure of zinc coatings on wire and sheet. The small corrosion laboratory is thoroughly equipped for carrying out chemical, microchemical, and micro-examination of specimens and corrosion products.

On the top floor of the old building is a general laboratory for light work not specially provided for elsewhere, such as glass-blowing and the construction of apparatus.

Metal Production by Electrolysis of Fused Salts

Further Investigation of Basic Principles

THE production of various metals by electrolysis of their fused salts has increased to a remarkable extent in recent years, and many improvements have been effected in the process; but according to Dr. Paul Drossbach, of the Berlin-Chlottenburg Electrochemical Institute, progress in basic research and elucidation of underlying principles has lagged behind the more practical or empirical developments. In his book on the subject, just published, he emphasises the great importance of this particular field of electro-chemistry and -metallurgy, especially for Germany. There can be no question as to the tremendous advance in electrochemical industries in that country, and especially in electrometallurgy. The annual production of aluminium there has now reached 150,000 tons, nearly one-third that of the whole world, which makes our own output look rather small.

In the book referred to the author discusses at some length the nature of the solution formed of metal in the molten salt, and expresses the view that R. Lorenz was in error in supposing that this solution was of the colloidal type. He goes so far as to say, in fact, that subsequent research has been hindered and misdirected as a result of this colloidal theory, though the value and importance of the pioneer work of Lorenz in this field is acknowledged. There is not space to discuss the latest views in detail here—a brief summary will be found in *Chem. Zeit.*, May 10, 1939—but later investigation of the binary system, metal salt-metal, shows that a true solution is formed, as is clearly evident from the recent work of van Laar and others; and that the analogy of very dilute solutions to gases envisaged by the van't Hoff school is not complete. From a consideration of intra-molecular forces and the most recent theory as to the nature of solutions Dr. Paul Drossbach considers there is little doubt that when the metal separating out during electrolysis is dissolved in the molten salt a true and not merely a colloidal solution is formed.

Influence of a Metal Solution

It is evident that the electrolysis of a fused salt is profoundly affected by this formation of a metal solution, and the process is quite different from that which takes place with aqueous solutions. If a current is passed through molten lead chloride lead separates out at the cathode, and owing to its solubility returns partly into solution. Through heat transference and especially stirring of the electrolyte by the chlorine set free at the anode this metal in solution is transported to the anode, where it reacts, partly at least, with the chlorine to reform chloride, so that there is definite loss of metallic lead. The factors governing this loss of metal are numerous and complex. According to Lorenz they included temperature, current density, and electrode spacing, but to these must now be added the absolute amount of electrolyte present and the size and perhaps also the shape of the apparatus, that is to say, of the electrolyte container. A further factor is the nature and extent of electrolyte flow or movement caused by temperature changes and evolution of gas. Generally it may be said that the losses of metal increase with temperature, amount of electrolyte, and rate of flow of the latter, while they decrease with increasing current density and electrode spacing. Rate of flow of electrolyte must obviously include the nature of frictional forces present, viscosity, etc., of the liquid which again will depend to some extent on the kind and size of apparatus used.

While therefore in the case of aqueous solutions experiments can be easily reproduced at constant temperature and current density, other factors enter with metal solutions and must be taken into account in comparing results of different investigators. Duration of test is very important. If for example, in the electrolysis of cadmium chloride, the metal is soluble in the melt up to 20 per cent. and over, it is at once clear that only metal can form at the cathode if the electrolyte is saturated with metallic cadmium; for so long as this is not the case any cadmium set free at the cathode must pass into solution. Current efficiency is also dependent on time, and must be calculated from the binary system standpoint. Hence it follows that many electrolytic dissociations of easily soluble metals may be undertaken with insufficient time allowance. Numerous tests by Drossbach have shown, in the case of cadmium, bismuth, and calcium, that there is a definite time relation with current efficiency; and further, the determination of anodic current losses is an important aid in the study of melt electrolysis. He has designed special types of apparatus for this purpose; and for the special study also of polarisation during electrolysis which is now generally realised to be so important. Among other things it has been found that the polarisation potential exhibits an over-voltage dependent on electrode material and current density, and even with low current densities it gradually increases with time.

Results with Mixed Electrolytes

In connection with metal refining some interesting results have also been obtained at the Berlin Electrochemical Institute in regard to mixed electrolytes, and the effect of additions such as potassium chloride to salt mixtures on the equilibrium state and on the final composition of an alloy. If the same current is passed through the same apparatus it is found, with short period tests, that

(1) In electrolysis of cadmium chloride no metal is obtained: it all goes into solution.

(2) With cadmium chloride and potassium chloride in equal weight ratio, metal is at once obtained with a current efficiency of about 74 per cent.

(3) With 74 per cent. lead chloride and 26 per cent. cadmium chloride, pure lead is obtained with a current efficiency of 88 per cent.

(4) With 20 per cent. lead chloride and 80 per cent. cadmium chloride there is an increasing amount of cadmium in the alloy. Anodic current yield and composition of alloy vary uniformly together, since cadmium is an easily soluble metal. If the anodic current yield is low there is less cadmium in the solution and *vice versa*.

(5) With 20 per cent. lead chloride and 80 per cent. cadmium chloride, to which 50 per cent. by weight of potassium chloride is added an alloy is obtained with only a very small content of cadmium. The marked displacement of equilibrium by addition of KCl is due to the fact that this addition has a more strongly negative effect with cadmium chloride plus potassium chloride than with lead chloride plus potassium chloride. With increasing current density the cadmium content increases.

These tests and others have shown how valuable is the study of the polarisation potential, and also the complexity of the electrolysing process with mixtures of metallic salts where the dissociation potentials are close together.

Emphasising the importance of research along these lines, Dr. Drossbach suggests that investigation should be directed, *inter alia*, to

(a) determination of equilibria state with the most varied or heterogeneous systems or salt mixtures;

(b) determination of conductivities and other characteristics of these binary, tertiary, and quaternary systems;

(c) measurement of individual potentials in the equilibrium state, and of polarisation during electrolysis;

(d) study of effect of current density and temperature on the anodic and cathodic processes.

Blast Furnace Slag

Wider Uses in Industry

A DISCUSSION by a special committee of the Verein Deutscher Eisenhüttenleute, held recently in the Haus der Technik, Essen, was concerned with the possibilities of making greater use of blast furnace slags. Papers were read and discussed on different phases of the subject and a report published in *Stahl u. Eisen,* from which the following points have been abstracted:—

Director W. Schafer estimated that the German blast furnace slag production in 1940 would reach about 20 million tons, or more than a ton for each ton of pig iron produced He said that hitherto, of the smaller quantity of slag produced, about two thirds had found useful application. Slag low in lime is used principally for road material as rubble, and for a pavement ingredient. Slag relatively rich in lime is used in the manufacture of cements known as "Iron Portland Cement" and "Blast Furnace Cement." A further quantity of blast furnace slag is used in the manufacture of furnace brick, artificial pumice, and slag wool. Research by Professor Kappen, of Bonn, has shown that finely milled blast furnace slag is a good lime fertiliser and in this direction large quantities could be utilised. A small part of the slag produced is utilised for filling in the excavated spaces in mines.

Dr. F. Hartmann, of Dortmund, pointed out that Thomas slags often contain valuable constituents, of which one is vanadium, which is being recovered from certain slags. Slags were said to contain a number of important properties which hitherto had been only imperfectly investigated. Dr. W. Korfeld, of Dortmund, estimated the present yearly production of furnace slags in Germany, including those of the iron, copper and lead smelting industries, at about 20 million tons, of which a good proportion was used in the building industry. He said that it was necessary to discriminate between the different kinds of slag as some were useful in one direction, and some in other directions, but there was no reason why any slag should remain unused.

Among the slag products used in the building industry are the slag-containing cements, furnace bricks, and honeycomb slag bricks. It was said that furnace bricks are well suited for cellar walls because of their bright colour, and because of very smooth surfaces and sharp angled corners they could be laid dry without setting in mortar or cement. The mortars and cements with a slag basis have proved very satisfactory. The honeycombed brick made of slag has also proved satisfactory, and it possesses the advantage of very small heat conductivity. Lately the use of furnace slag pumice for concrete of a light character has been developed. Slag wool is an excellent insulating material against heat, cold, and sound, and it is probably the most useful of all the slag products. Its properties include those of freedom from bacteria, smell, and resistance to fire, and these properties make it a very important trade material. Slag is also used in large quantities for plastering purposes; about a quarter of the total German slag utilised is in road construction and for concrete, and for this, slag with a lime content below 45 per cent. and a silica content of 29 per cent. or more, is the most suitable.

Dr. B. Grün, of Düsseldorf, referred to the manufacture of cements from blast furnace slags. For this purpose latent hydraulic, water-granuled blast furnace slag, mixed with some Portland cement, is known as "furnace cement" because it is produced in the smelting industry. Furnace cement equals Portland cement in strength, and the properties of the two kinds are very similar. The shrinkage of furnace cement is very small, so that roads cemented with this material do not develop cracks. Blast furnace cement is suitable for resisting the corroding action of sea-water because of its relatively low lime content. The production of cement from blast furnace slag was introduced originally as a means of disposing of a troublesome by-product of the iron industry, but later it was found that the cement made from slag possessed certain valuable properties of its own.

Annual Tin Figures

Decrease in World Production during 1938

TIN statistics for the year 1938 are given in the "Statistical Year Book, 1939" of the International Tin Research and Development Council. The figures cover the production, stocks and prices of the metal and its consumption in the various countries for numerous applications—over a long period of years.

The sharp downward trend of world trade which began in August, 1937, continued during most of 1938 and the recovery in the second half of the year had ceased by November. In the year 1937 world production of tin reached the record figure of 208,000 tons, but in 1938 the figure was 148,000 tons. In spite of this decrease of nearly 30 per cent. it must be borne in mind that 1937 was an exceptionally prosperous year, and comparing the 1938 production with the average for the period 1926-1936, it will be found that 1938 does not make a bad showing.

Curtailment in production has imposed a heavy burden which has been borne entirely by the signatory countries. The following table gives a review of the average annual tin production of the seven countries adhering to the International Tin Control Scheme, as compared with that of the outside countries.

	Average Annual Tin Production of the Seven Signatory Countries.		Average Annual Tin Production of Other Countries.	
	Long tons.	% of total.	Long tons.	% of total.
1926-1930 ..	151,000	89	18,000	11
1931-1933 ..	95,700	85	16,500	15
1934-1936 ..	123,600	84	23,200	16
1937-1938 ..	149,500	84	27,900	16

This shows that in the last ten years production of non-signatory countries has increased by about 10,000 tons. The increase is mainly the result of larger outputs by countries which have produced tin for years and is due only to a minor extent to the exploitation of new occurrences.

Countries which have increased their output in the last decade are: China, whose annual exports increased by 4,000 tons; Japan, where the output rose from 900 tons in 1928 to 2,200 tons in 1938; and Burma, where production increased from 2,300 tons to 4,000 tons.

In Europe mine production is at present less than 2 per cent. of the world total. Whereas, thirty years ago, Europe still produced 5,000 tons per annum, this quantity has now fallen off to 3,000 tons. Consumption, on the other hand, is on the up-grade, and now amounts to 75,000 tons per annum as against 60,000 tons thirty years ago.

As regards Asia and Oceania, the figures show quite a different picture. About 70 per cent. of the total world output is obtained from these parts, whereas consumption does not exceed some 15,000 tons per annum corresponding to 9 per cent. of the world total.

In North and South America combined, consumption is more than double the mine production. Production has risen from a pre-war output of 20,000 tons per annum to 30,000 tons in the post-war period, while consumption increased from 44,000 tons to more than 70,000 tons.

In Africa mine production has extended considerably in the last thirty years. Prior to the war the annual output was somewhat above 2,000 tons, but has since risen to 18,000 tons in the years 1935-1938, corresponding to 10½ per cent. of the world-total. Consumption amounts there to about 1,400 tons per annum.

The arrangements for the 6th annual conference of the Institute of Vitreous Enamellers to be held at the Grand Hotel, Birmingham, on September 22-24 next, are now being made by the Conference Committee. The following provisional programme is tentatively arranged:—

Friday, September 22: Works visit to various enamelling plants in midland area; annual general meeting; annual banquet.

Saturday, September 23: Technical papers; theatre party; supper.

Sunday, September 24: Works visit midland district.

Metallurgical Section

August 5, 1939

Current Topics

Iron Ore Treatment in the Saar

IRON ore deposits which will ultimately satisfy a considerable portion of the Saar requirements have been under discussion in different directions on the Continent, having already come in for detailed consideration at a meeting of the Saar branch of the Association of German Iron Metallurgists early this year. These ores are mined and dressed by the Dogger Erz-Bergbau, a concern which has been capitalised by all of the Saar iron and steel plants. The deposits are said to contain about 400 million tons of ore, and the annual mining capacity amounts at present to 1.2 million tons but will be increased to 1.8 million tons. The ore has an iron content of 20 per cent., but needs additional care due to its high moisture content and softness.

Two different dressing processes are applied, namely, the Lurgi-Groeppel process, in which the ore is roasted in a rotary furnace, and the Roechling process, which requires the roasting of the ore in shaft furnaces. The Lurgi-Groeppel process necessitates the crushing of the crude ore to under 20 mm. before roasting it, and the roasted ore is again crushed and the iron concentrates are then extracted by means of magnets. This process, however, is very expensive, and it is for this reason that the Roechling process may be given preference. The Lurgi-Groeppel ore dressing plant at present in operation has a daily capacity of 900 tons of ore, and from 250,000 to 300,000 calories are required for the dressing of one ton. The concentrate has an iron content of 42 per cent. and the recovery is about 80 per cent. In the Roechling process from 80 to 85 per cent. of the roasted product is lump ore with an iron content of 24 per cent., and 15 to 20 per cent., the pulverised ore with an iron content of 29 per cent., the pulverised ore being formed into briquettes. It is said that the Saar iron industry is to smelt about 3.6 million tons of Dogger ore in the near future, from which 700,000 tons of pig iron could be produced. For 1938 the output of the Saar iron industry was 2,380,000 tons of pig iron, or about 13 per cent. of the total German output.

Zinc Import Duty

The increase in Customs duty on unwrought zinc from 12s. 6d. per ton (or 10 per cent. *ad valorem*) to 30s. per ton as from May 26, 1939, applied on the recommendation of the Import Duties Advisory Committee, is one of a number of proposals made by the committee in a report to the President of the Board of Trade in February last, for amending the arrangements which were introduced in 1935 following an earlier inquiry by the committee into the working of the agreements regarding lead and zinc which were concluded at the Imperial Economic Conference at Ottawa in 1932. The duty of 12s. 6d. per ton, hitherto applying to foreign zinc, was imposed on the recommendation of the committee in 1935 following an inquiry by them into the difficulties which had arisen under the original Ottawa agreements for lead and zinc. As the continued low price of zinc coupled with increasing costs of production had a serious effect on the position of the Imperial Smelting Corporation, whose production was not to exceed 60,000 tons per year, application was made to the committee in 1936 for a higher rate of duty on foreign imports in order to establish a more satisfactory price level in this country. The committee, however, considered that the position could not be met by a higher duty alone, and suggested the desirability of an Empire agreement as a first step. As a satisfactory basis of agreement could not be found, it was in 1937, following an inquiry held by the Committee of Imperial Defence, that the Import Duties Advisory Committee were asked to promote discussions between the United Kingdom and other Empire producers.

Oxidation and Decarburisation of Steel

With a view to crystallising the present position of knowledge relating to the influence of alloy elements on scaling, and on the surface decarburisation of steel at elevated temperature, H. Schrader has published a systematic survey of the work which has been done by a large number of investigators (*Stahl und Eisen*, 1939, *59*, 473). The effects of aluminium, beryllium, boron, cobalt, chromium, copper, nickel, manganese, molybdenum, phosphorus, silicon, titanium, vanadium, tin and tungsten have been considered individually. Small amounts of nickel, either alone or in conjunction with other elements, have been found to have a progressively beneficial effect on resistance to scaling, but the influence of small percentages of nickel on surface decarburisation is less clearly defined since the results of different investigators show some discrepancies. The present survey, which is based on data from more than fifty sources, indicates that while the conclusions drawn from the various investigations are in general agreement with reference to the influence of the respective elements on scaling, there is considerable diversity of opinion with regard to the effect of various elements on the susceptibility of steel to surface decarburisation. The author's own experimental work upon the subject is included, and he discusses possible reasons for the divergent results.

Protective Coatings for Metals

For twenty-five years past the development of protective coatings for metals has engaged close attention, but investigations have been greatly intensified during the last few years. The variety of metals which have need of protection, and materials and methods used, has now become so wide that only the specialist is able to keep fully informed as to the present position. The publication of " Protective Coatings for Metals," by R. M. Burns and A. E. Schuh, as one of the volumes

in the American Chemical Society's Monograph Series (Reinhold Publishing Corporation, New York) is therefore especially welcome, because the chief purpose of this book is to meet the needs of engineers, chemists and works executives who must decide what methods should be used to protect various metals under the conditions to which they will be subjected in service. This book will be found far more comprehensive than the valuable monograph by H. S. Rawdon, "Protective Metallic Coatings," which was published in 1927, to which it comes as a successor rather than as a revision. The joint authors have given a very critical review of the literature and practice of the subject concerned, and they have undoubtedly rendered a great service to science and to industry. Following certain main aspects of the subject, such as the mechanism of corrosion, surface preparation, types and methods of application, and particular reference to coatings of zinc, cadmium, tin, nickel, chromium, copper, lead aluminium, silver and platinum, and methods of testing metallic coatings, there are three chapters devoted exclusively to the composition, application, and evaluation of paint coatings on metals, and also a chapter upon oxide and phosphate coatings and vitreous enamels. The fact that over 700 names are given in the index shows that the authors have endeavoured to gather in all possible sources of information.

Metallurgy and Petroleum Refining

The continued growth of the petroleum refining and cracking industry shows signs of making heavy calls on the resourcefulness of the metallurgist. Due to the higher temperatures and pressures which are likely to be employed, it is probable that all types of corrosion will be greatly accelerated. At present the severest conditions are found in cracking stills, particularly in the heating tubes and reaction chambers. Internal corrosion of the heating tubes is mainly due to the hydrogen sulphide produced from cracking, and this is most reactive at temperatures of about 400 to 450° C. and notably less at 510° C. External corrosion by oxidation, however, is least at the lower temperatures range and much more marked at the higher temperature. The failure of the metals used for the construction of cracking equipment is due to chemical and physical changes taking place at high temperatures. According to Dr. Gustav Egloff (*Chemical Industries*, 1939, 44, 23) alloy steels have largely replaced carbon steel tubes in modern pipe stills, as well as in pipe connections to the vessels, primarily to reduce corrosion but with the advantage of greater mechanical strength. The choice of the alloy is largely a question of economics and the balance between the advantages gained with expensive alloy and the less expensive steel.

Pearlitic steel alloys have been adapted to high temperature high pressure service under corrosion and oxidation conditions, and there is no longer the necessity to keep to the use of austenitic alloys as was the case a few years back. This advance in alloy steels was accomplished by the addition of 0.5 per cent. molybdenum with from 1 to 5 per cent. of chromium. The chromium is kept from combining with the carbon present in the steel by the addition of stable carbide-forming elements, such as titanium and columbium, which makes the alloy resistant over a wide range of corrosion conditions. The addition of titanium, silicon and aluminium alone or in combination, has imparted to the pearlitic steels high oxidation resistant properties that—within a wide range of temperatures—are as good as those attributed to austenitic steels alone. For reaction chambers, an addition of 1 per cent. of molybdenum to low carbon steel practically doubles the strength of these vessels at temperatures of 475° C. and upwards.

Nickel Alloy Cast Iron

Some factors involved in hardening and tempering grey cast iron were discussed by G. A. Timmons, V. A. Crosby and A. J. Herzig in a paper read before the American Foundrymen's Association. Changes occurring on hardening and tempering of cast iron were studied on an unalloyed iron and on alloy irons containing molybdenum, nickel and molybdenum, chromium and molybdenum, and nickel with chromium and molybdenum. The irons were heat-treated in the conventional manner, by flame hardening, and in a manner especially designed to study the effect of quenching temperature on combined carbon content. The results of the experiments show that graphitisation of unalloyed pearlitic cast iron takes place rapidly at temperatures from 700 to 800° C., and that resolution of graphite at temperatures above the critical point takes place rapidly. Special attention is directed to inherent differences between iron and steel, which vitally affect the response of the respective materials to heat-treatment. The combined carbon content of the iron, as cast, is without effect on the carbon concentration in the austenite at the instant of quenching. The quenching temperature, duration of heating and chemical composition are the deciding factors. The influence of alloys on the rate of graphitisation is claimed to be a useful means of controlling hardenability. Tabular and graphical data which the authors presented indicate that the effect of the respective alloys on hardenability of cast iron parallels their known effects in steel. The quenching and tempering of grey cast iron effectively increases hardness and tensile strength, but such enhancement of properties is obtained at some sacrifice of shock resistance, transverse strength and deflection.

THE MAINTENANCE OF LIFTING TACKLE

Until the coming into force of the Factories Act, 1937, the majority of factory occupiers were probably free from any legal obligations respecting the regular examination and maintenance of chains, ropes and other lifting tackle. Only when the premises were within the scope of certain regulations for dangerous trades was the occupier legally obliged to give his attention to the matter.

The new Act has changed this. What used to be a voluntary item of safety practice has now become a matter of law. Sections 23 and 24 of the Act lay down very definite requirements covering the lifting tackle used in every factory.

The result has naturally been a great increase in the amount of interest shown in the subject. For this reason the National Safety First Association decided that one of the sessions at its recent safety congress, held at Caxton Hall, Westminster, should be devoted to a paper by Mr. G. Dixon, J.P., who is chain inspector of the London Brick Company, Ltd. The report of this session has now been published in booklet form. Mr. Dixon's paper is reprinted in full and the contributors to the discussion include men who have expert and practical knowledge of the safety problems connected with lifting tackle of all kinds.

COPPER AND ARMAMENTS

British and American Influence in World Output

By

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THE vital importance of copper in the armament industry and in the conduct of modern warfare is not so widely recognised as might be expected, although such a phrase as " the mechanised army " is a reminder of the extent to which modern engineering practice and technique are employed in the construction, equipment and maintenance of the weapons of war.

By far the greater proportion of the copper produced in the world is used in the electrical industry, and for almost all the purposes of this industry a high purity metal is essential. The employment of copper for electrical purposes depends entirely on its two most outstanding properties, namely its high conductivity and ductility. So far as electrical conductivity is concerned, copper is second only to pure silver, and while it is not so ductile as pure gold, it is one of the metals which can most easily be drawn into fine wire. Electric motors, telephones, wireless transmitters, cables and generators constitute only some of the almost innumerable demands for high purity copper.

Copper is also employed, although to a smaller extent, in the manufacture of brasses and bronzes for tubes, valves, propellers, and for all parts subject to attack by corrosion. Cupro-nickel alloys are used for condenser tubes, steam-turbine blading and electric resistance elements. In the preparation of the aluminium-light alloys copper forms an essential constituent. Only 4 to 5 per cent. is commonly employed, but this small amount is absolutely necessary to produce the light alloys which will stand up under the very severe operating conditions which prevail in modern motor-car, compression-ignition and aeroplane engines. It can be said quite truthfully, then, that copper is one of the very important sinews of war. The truth of this can easily be substantiated by the figures for the consumption of the metal in Japan, which has been engaged for several years back, in almost continuous warfare in the Far East. The consumption of copper has risen from 69,000 tons in 1930 to 135,000 tons in 1935 and to 195,000 tons in 1937. There were 110 copper mines in operation in the country in 1932, and large quantities of the metal are smelted in the country from home-produced and foreign ores, but the actual amounts of metal smelted were 68,000 tons in 1935 and 86,000 tons in 1937, so that the amounts imported have risen from 67,000 tons in 1935 to 109,000 tons in 1937. If the severe economic conditions operating in Japan are borne in mind then it will be evident that the expansion of the imports of one metal by over 40,000 tons would only be permitted if the additional amounts were absolutely essential.

The consumption of copper in the great countries of the world was as follows during 1936 and 1937 (in metric tons) :—

	1936	1937
U.S.A.	733,900	785,000
Britain	258,000	305,000
Germany	183,000	205,000
France	113,000	123,000
U.S.S.R.	128,000	140,000
Italy	75,000	65,000
Japan	127,500	195,000

The increase in the consumption with the rearmament programme can be noted in the case of Britain, in which a 20 per cent. increase occurs from 1936 to 1937. The increase is even more noticeable if the imported amounts are studied, imports were 287,000 tons in 1936 and rose to 390,000 in 1937. The fact that a drop in imports to 354,000 tons occurred in 1938 can probably be explained by the gradual accumulation of stocks.

The sources of copper and the availability of supplies is a question of outstanding importance. The largest producer of copper in the world is the U.S.A., where in 1937 out of a total production of 2,290,000 tons, 807,000 tons or 35 per cent. of the world total was recorded. The amount of the metal exported from the States that year was just about 300,000 tons. There are also large copper deposits in South America, located at Chuquicamata, 162 miles north-east of Antofagasta in Chile, from which 406,000 tons or 17 per cent. of the world production was exported These deposits are owned by the Chile Mining Co., Ltd., which is owned almost entirely by the Anaconda Copper Mining Co., of the U.S.A. In 1938 124,000 tons of copper were imported into Britain from Chile. The ore reserves at December, 1936, were over 1,000 million tons with an average of 2.16 per cent. of copper, or over 21 million tons of metal. This ore-body which measures $2\frac{3}{8}$ miles in length by $\frac{3}{8}$ of a mile in width is the largest single deposit of copper ore in the world.

The copper smelter at Ronnskar, North Sweden. Varying quantities of copper are shipped to Germany.

In one of a series of monographs of the Resources of the Empire published by the Federation of British Industries, the following statement is made regarding copper : " The British Empire is only a small contributor to the world supply, the production of the U.S.A. alone being about 5 times the amount." This was written in 1924 and in the 15 years which have elapsed the position has been radically altered, for even in 1937, the production of copper from the British Empire was over 460,000 tons or just over 20 per cent. of the world total, and constituted the second largest quota on the list. This phenomenal increase in the production of copper within the Empire has been due to the development of the copper deposits in Noranda, Quebec, and Flin-Flon, Manitoba, and the copper-nickel deposits at Copper Cliff, Ontario in Canada, together with the discovery and development of the deposits in Northern Rhodesia.

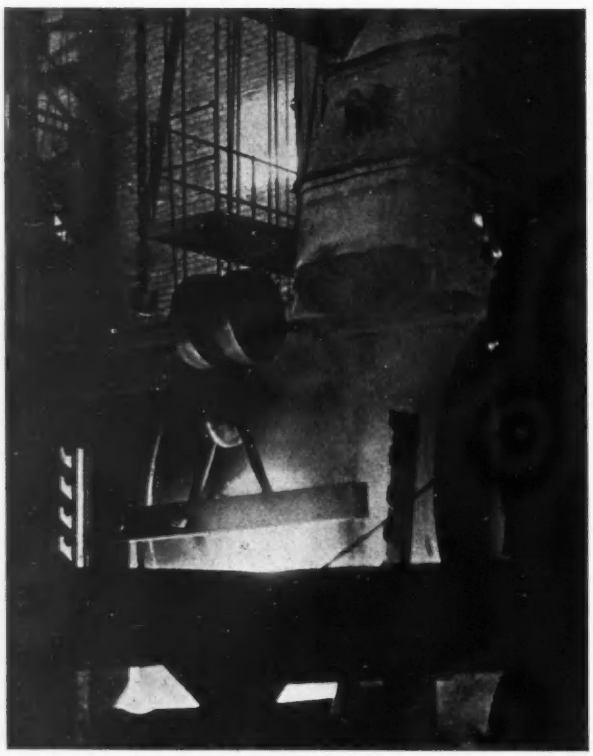
These Rhodesian deposits are found in a strip of country 140 miles wide adjoining the Katanga boundary of Belgian Congo. There are 8 commercial deposits which operate as three units : The Roan Antelope Copper Mines, Ltd., Rhokana Copper Mines, Ltd., and Mufulira Copper Mines, Ltd. These deposits are in rather inaccessible country, the

distance to the port of Beira being over 1,700 miles, but roads and railways are rapidly being laid, as the properties are being extended. Concentrators and smelters are installed at each property and smelting began at Roan Antelope in 1931, at Rhokana in 1932 and at Mufulira in 1937. The smelter at the latter is being extended to a capacity of 96,000 tons of metal a year. The following table gives the copper production at each property for the year 1937-38, the ore reserves and the average copper value of the ores.

Company.	Copper smelted.	Ore Reserves. (tons).	Copper Content.
			%
Roan Antelope Copper Mines, Ltd.	75,253	87,498,099	3.43
Rhokana Copper Mines, Ltd.	76,275	117,957,672	3.44
Mufulira Copper Mines, Ltd.	52,436	156,499,000	4.11

Imports to Britain from Northern Rhodesia were 109,000 tons of copper in 1937 and 89,000 tons in 1938.

A new property is in course of development. It is known as Nchanga Consolidated Copper Mines, Ltd., and



An important stage in the production of copper—the crude metal pouring from the converter.

was formed in March, 1937. It has estimated ore reserves of 143,780,000 tons with an average of 4.66 per cent. of copper.

The production costs at these properties must be about the lowest in the world, the cost of producing electrolytic copper at Rhokana works out at 2.6d. per lb., a figure which compares very favourably with 7 to 12 cents. (3½ to 6d.) per lb., which is common in American practice. In view of all these facts and of the magnitude of the reserves there can be little doubt that these deposits will form one of the most important sources of copper for many years to come, and it is very probable that even the colossal figures for the ore reserves may be exceeded in the future.

The provision of supplies of copper adequate for the huge armament programme must be a matter of considerable difficulty in Germany. The story is going the rounds of the two Czech engineers who were reproved in no uncertain tones by the German foreman for idling and adduced as the good and sufficient reason for their behaviour that they were waiting for the next consignment of copper. Even during the Great War Germany experienced very great difficulty in obtaining sufficient supplies of copper and these have not grown less with the passing of the years. The only internal source of ores are the Mansfield deposits in Central Germany and the Rammelsburg mines at Goslar near Hanover. Both are quite uneconomic under modern conditions, but both are being worked in the drive for autarky. The Mansfield operations have been heavily State-subsidised for the past 10 years, or production would have been impossible. Another source of supply is the treatment of "burnt pyrites" for the extraction of the copper. Large amounts of cupriferous pyritic ores are imported, the sulphur is recovered as sulphur dioxide and used in the manufacture of sulphuric acid and oleum, and the residues treated for copper. The amounts of such ores imported have risen from 394,000 tons in 1935 to 546,800 tons in 1937. The amounts of copper produced from these and internally produced ores has risen from 55,700 tons to 64,500 tons in the same period. The principal sources of these pyritic ores are Spain and Norway. From the mines at Huelva and Badajoz over 183,000 tons of pyrites were exported in 1935, the last year for which figures are available. From Norway about 350,000 tons of pyritic ores were exported during 1937, and a good deal of this was consigned to Germany.

But large quantities of copper are required over and above supplies which can be obtained in this way and 167,000 tons of copper were imported in 1937. One reason, at least, for the pressure which has been brought to bear on Jugoslavia by the "Axis" in recent months can be found in the fact that there is exported from that country about 37,000 tons of copper per year, and such an amount would form a very useful addition to the scanty supplies which are available to those powers. The operating firm is the Mines de Bor, and it is perhaps not without significance that the plant is being extended to a capacity of 5,000 tons of metal per month. From the Rio Tinto mines in Spain small, but welcome, supplies of the metal will also be available under the Nationalist Government of Franco. The firm operating at Rio Tinto is British, but already the profits have been "immobilised" in unconvertible pesetas in Spain, evidently Nationalist Spain is going to be aligned with the "Axis" powers and her resources will no doubt be made available to them.

Less British Copper for Germany

From Sweden and Finland small supplies of copper can also be had. Finland started the production of metal in 1936, and in 1937 10,428 tons were smelted. About 10,000 tons are annually exported from Sweden. The most important source in Sweden is the copper-gold deposits at Boliden, owned by the Boliden Mining Co. A gradually increasing tonnage of copper is being exported from their smelter at Ronnskar in the north of the Baltic Sea. One country from which Germany is importing less and less copper and copper manufactures is Britain. The amounts exported to Germany were 925,000 cwts. in 1936, 145,000 cwts. in 1937 and 48,778 cwts. in 1938. While for the five months up to May 31, 1939, the amount is only 3,658 cwts.

Whatever the position may become in the future, it would appear that for the present, and in the event of war in the near future, Germany will again experience the same difficulty in obtaining adequate supplies of copper as was her lot during the last war.

ALL of the gases from the zinc smelters of Consolidated Mining and Smelting Company of Canada, Ltd., at their Trail reduction plant are treated for the recovery of their sulphur content. During 1938 two 120-ton American sulphuric acid units were put into service and the sulphuric acid capacity is now placed at 600 tons of 100 per cent. sulphuric acid daily. A third 50-ton reduction unit has been added to the sulphur plant, and a fourth centrifuge added to the ammonium sulphate plant. The production of sulphur and fertiliser in the chemical plants during 1938 was 170,108 tons, as compared with 115,586 in 1937.

Expansion of British Electro-Chemical Industry

Increased Efficiency of Thermal Power Stations

THE possibility of further expansion of electrochemical and electrometallurgical industries in this country has lately received considerable attention, and is well worth study from every point of view, both economic and military. (In its broadest sense electrochemical includes the metallurgical divisions, and is to be so understood in the following brief survey.) Under the stimulus of re-armament much has been already done in some directions, e.g., some of the more important light metals and alloys are now being produced in ever increasing quantities, as the recent report under the Import Duties Act clearly indicated, such as ferro-manganese and spiegeleisen, ferro-tungsten, and other ferrous alloys. Manganese, too, as shown in the latest minerals report issued by the Imperial Institute, is being manufactured here on a much larger scale, under various new and interesting processes. But it is considered that there is yet plenty of room for further development in these and other lines.

No Reason for Backwardness

The main point in these suggestions is that the reason usually advanced for our supposed backwardness in electrochemical industry, namely, that of almost complete absence of cheap hydro-electric power, is no longer valid or has lost much of its cogency, largely due to the remarkable increase in efficiency of steam or thermal power stations in recent years; so much so, indeed, that in many cases the balance of advantage is now on the side of the thermal station when compared with the hydro-electric installation. Broadly speaking it may be said that many of the best sites for hydro-electric power in most countries have been already taken, and that the disadvantage of remoteness amounting almost to inaccessibility in the matter of raw materials on the one hand and markets for the finished products on the other, has become more acute; in the second place, the cost of electric power in many electrochemical operations is often a comparatively small factor; and in the third place the capital costs of a thermal station are, as a rule, considerably less than those of a hydro electric plant, in view of the present high efficiency of the former.

It is worth while to consider these points—at least the second and third—a little more in detail, especially if one takes fully into account the vital national importance of these industries under present world conditions. The cost of electricity as a percentage of the selling price of the product has been the subject of many statistical studies, and some of the latest approximate figures are as follows: 0.5 to 0.9 per cent. in the production of cadmium and in the refining of copper, nickel, and lead; 1.1 per cent. for ferro-tungsten; 4 per cent for copper extraction; 8-9 per cent. for magnesium (probably less under the latest methods); 11 per cent. for certain important chemicals such as chlorine, caustic soda, and potassium chlorate; 12 per cent. for ferro-manganese; 13 per cent. for aluminium; 17 per cent. for zinc; 18 per cent. for calcium carbide; 20 per cent. for ferro-chrome; and 27 per cent. for ferro-silicon.

The third point, that of relative costs of electricity from thermal power stations and from hydro-electric sources, has also been the subject of elaborate statistical investigation in recent years; and the remarkable advance in efficiency of thermal or steam power during the last decade needs little emphasis at this time. In general terms it may be said that the cost of electricity, generated at a thermal station of the latest approved type erected at a capital cost of £18 per installed kW, is likely to be about the same as that obtained from a hydro-electric station erected at a capital cost of £49 per installed kW. This latter may be considered a comparatively low figure, and could hardly be achieved in Great Britain, nor in many places abroad where such stations are established. It thus seems legitimate to conclude that a modern thermal station can deliver electric power on equal terms with, and sometimes on lower terms than, a water-power station; and it is not necessary to elaborate certain other important advantages, such as easier access to raw materials and markets, and no anxiety on the score of water shortage.

It is not, of course, intended here to go to the other extreme and under-rate such advantages as the existence of "white coal" resources may offer; but it does seem reasonable to suggest that, even where the percentage cost of electricity in the final cost of the product is fairly substantial, a case may sometimes be made out for the establishment of an electrochemical industry where the only available source of electricity is a thermal station; and should provide a further outlet for our coal which, after all, still is one of our greatest national and natural assets.

Among the various lines along which these suggestions could perhaps materialise most fruitfully are certain chemicals which to-day more than ever before are continually demonstrating the advantages and efficiency of electrolytic methods of production, including, for example, chlorine, caustic soda, various per-compounds, such as hydrogen peroxide and the perchlorates, possibly even oxygen and hydrogen from electrolysis of water—though here the costs of electric power are very high—also several metals and alloys, such as aluminium and magnesium and their alloys; and the so-called minor metals (sodium, calcium, lithium, beryllium, and cerium), ferrous alloys, and abrasives of various kinds. Calcium carbide might perhaps be included, but this and probably also some of the products enumerated above, are already receiving close practical attention. The urgent need for the manufacture of these and many other materials at home has so long been known and emphasised that it is needless to labour the point further.

Germany's Great Advance

One further aspect of the subject that does require the strongest emphasis possible is the fact that there is hardly any other country that has made greater advance in electrochemical industry in recent years than Germany, and this has been achieved not on cheap hydroelectric power but on her own coal and lignite resources and efficient thermal power stations. Her production of aluminium alone is now 150,000 tons per annum, nearly a third of the world's total, as compared with our 25,000 tons.

The Montreal correspondent of *The Financial Post* (Toronto) reports that the Aluminium Company of Canada intends to spend $7,000,000 between now and next May on the expansion of their plants at Arvida and Shawinigan Falls, in Quebec, and at Kingston, in Ontario. The programme will provide not only a new plant for the construction of hard alloy, but will increase the ingot capacity of the Quebec smelters by 15 per cent., or from somewhat over 150,000,000 lb. to more than 175,000,000 lb. annually.

At Arvida additional smelter or pot rooms are being installed for the manufacture of aluminium. This also involves an increase in bauxite storage facilities. At Shawinigan Falls, the smelter is being modernised and new pot rooms installed. The Kingston establishment will be equipped to manufacture plates, sheets, strip, structural shapes, rods, moulding, tubes and other semi-finished forms of aluminium alloys.

Some Recent Metallurgical Patents

Lead Alloys

A lead alloy consists of 0.01-0.1 per cent. calcium, .01-0.3 per cent. magnesium, and 99.6-99.98 per cent. lead. Lead in quantities 0.03-3 per cent. may be replaced by an equivalent amount of one or more of the metals cadmium, mercury, and tin. The alloys may be used for making cable sheaths and battery grids. (See Specification 499,549 to American Smelting and Melting Co.)

Galvanising Flux

A flux for use in galvanising contains aluminium oxide together with ammonium chloride, zinc ammonium chloride, or zinc chloride. It may also contain one or more other metal oxides, *viz.*, lead oxide, stannic oxide, iron oxide, bismuth oxide, copper oxide, or cadmium oxide, metallic zinc or aluminium, or zinc-aluminium alloys, fluorine compounds, alkali chlorides, and alkali aluminium chlorides. The aluminium oxide may constitute about 1 per cent. by weight of the flux. The flux may be used with molten zinc or zinc-aluminium baths, or it may be used on the surface of the molten lead in a lead-zinc galvanising bath, in which case the zinc layer may contain aluminium. The constituents of the flux may be fused on the surface of the bath or may be applied to the surfaces of the articles to be coated. Where rollers are used to handle the articles, the flux may be used to clean the rollers. (See Specification 499,149 to Liban, T.)

Lead-Refining Processes

Spent alkali metal hydroxide reagent from caustic-alkali lead or lead alloy refining processes is mixed with a limited amount of water to form a sludge and treated with calcium hydroxide at a temperature less than 80° C. and preferably at room temperature, the solid matter containing oxysalts of calcium being removed from the resulting liquor. The limited amount of water is preferably insufficient to permit sedimentation of metal prill in the sludge and preferably not substantially greater than that necessary to dissolve the free soda. Metallic prill is removed together with the oxysalts and may be separated later. The oxysalts may be smelted with charcoal, sand, and fluorspar to recover the metal. The process is applicable to both caustic soda and caustic potash. (See Specification 499,610 to National Lead Co.).

Improving Iron

To improve the strength and abrasive properties of iron, a mixture of 11.32 parts by weight of calcium carbide, 2.66 of aluminium and one of magnesium or 34 parts of calcium carbide, 16 of aluminium and 3 of magnesium is added to molten iron preferably in the proportion of five pounds of either mixture per ton of metal. For the production from ordinary foundry iron mixture of castings giving a tensile strength of from 14 to 16 tons per sq. in. or for castings produced from high silicon manganiferous pig iron, hæmitite and scrap and having a tensile strength of 16-19 tons per sq. in., the first mixture is used. For the production of castings having a tensile strength of 19-22 tons per sq. in. or from 20-25 tons per sq. in., the second mixture is used, but in the latter case ten pounds of mixture per ton is used. (See Specification 499,647 to Croft, A.)

Decarburising Nickel

Commercial nickel or cobalt containing above 0.2 per cent. of carbon is decarburised by heating to a temperature above 1,000° C. and below the melting point, preferably not over 1,300° C., in a non-reducing, preferably an oxidising, atmosphere, so that the final product contains less than 0.05 per cent. of carbon. The final product may be used for the production of ferro-alloys which are as free from carbon as possible. In an example an alloy produced contains 0.02 per cent. of carbon, 49.5 of iron, 5 of copper, 10 of aluminium, 22.5 of nickel and 13 of cobalt. (See Specification 499,677 to Bosch Akt.-Ges., R.)

Coating Metals

An artificial patina is formed on copper and its alloys by treating the metal, while exposed to air, two or more times with one or more chlorine derivatives of sulphur acids, such as thionyl chloride, sulphuryl chloride, or chlorosulphonic acid. A solution of the chlorine derivatives in a volatile solvent such as carbon tetrachloride or benzene may be used, and the interval between the treatments is preferably not less than a day. The metal treated may be bright or may be blackened or partially patinated by previous exposure. (See Specification 499,907 to Vernon, W. H. J. and Stroud E. G.)

Alloys

A hard alloy for tools, dies, ignition contacts, and other purposes consists of tungsten carbide containing up to 2.5 per cent. of vanadium carbide, with or without titanium carbide, and a bonding medium consisting of an alloy of vanadium, with one or more lower melting point metals such as cobalt, nickel, iron, or manganese. The alloy may be made by adding to a mixture of ammonium vanadate, titanium oxide, and tungsten sufficient carbon to reduce the compounds and to form the required carbides of titanium, vanadium, and tungsten, and heating in hydrogen at 1,800° C.; the product is powdered, reheated at 1,800-2,000° C., mixed with vanadium powder or canadium compounds and an oxide of a metal such as cobalt, and reduced in hydrogen at 350-400° C. The resulting alloy is ground and ball-milled and the powder is pressed to the desired shapes and sintered. The powder before pressing may be mixed with diamond dust and formed into grinding wheels, drills and the like. (See Specification 499,789 to Laise, C. A., and Rogers, M. F.)

NICKEL AMALGAM

In *Bull. Soc. Chim. de France* (1939, 5, 864-6), J. Bougault and others point out that nickel, even when pulverised and however long and vigorously stirred, does not amalgamate with mercury. Referring to the work of previous investigators, dating back to that of Böttger in 1834, they find that this amalgamation has been effected in various indirect ways, such as that of W. Ramsey by electrolysis of a solution of nickelous chloride with a mercury cathode. More recently J. Aubry (*Bull. Soc. Chim.* 1937, 1,074) reported the direct formation of nickel-mercury amalgam, using Raney nickel. The prior methods referred to appear to have one characteristic in common: the presence of nascent hydrogen.

The present authors have undertaken experiments to see if hydrogen from another source would be equally effective, and have found that it is sufficient to treat the nickel with fairly strong acid, such as hydrochloric or dilute sulphuric, in the presence of mercury, and stirring. Amalgamation is thus readily accomplished. A small quantity of acid is sufficient; the nickel progressively disappears, and the mass becomes homogeneous, and of a density more or less great according to the proportion of nickel present. Amalgams were prepared with nickel content varying from 10 per cent. to 80 per cent. Hydrogen appears to play the role of catalyst, but has to be present in a certain condition. The nickel amalgams are a brilliant white when freshly prepared, and so long as they are kept under water or otherwise out of contact with air, but on exposure to air they slowly oxidise. This is much the more rapid with hydrogen peroxide, as one would expect, and this agent is rapidly and violently decomposed. If stronger acid is used the amalgams retain some hydrogen which disappears under vacuum with considerable swelling of the mass. Again, if the amalgam is heated or distilled in vacuum, and the mercury thus released is allowed to fali back on to the residue, it combines immediately therewith to reform the amalgam. The nickel separated in this way by distillation is not pyrophoric, and differs in this respect from nickel obtained by distillation of amalgams prepared from Raney nickel.

Metallurgical Section

September 2, 1939

Current Topics

Steel Exhibits at New York

Steel exhibits at the World's Fair at New York show that the development of high tensile stainless steel is furnishing a new engineering material for the railway and aviation industries, with great beneficial effect in the matter of design, performance and operating expense. New alloy steels for high temperature service are assisting in attaining high efficiencies in steam power plants and also providing efficient equipment for the refining of petroleum and for other processes in the chemical industries. Further progress is seen in the development of high quality deep drawn steel sheets having high resistance to atmospheric corrosion and high tensile strength, and which are easily workable and weldable.

Recent developments of the Bethlehem Steel Corporation include a process of controlled cooling for rails, which gives almost complete assurance against that extremely dangerous type of rail failure known as the transverse fissure. The Bethanizing process of electrolytically applying a zinc coating to wire has now been extended to the zinc coating of sheets. The Fansteel Metallurgical Corporation has perfected the adoption of tantalum for heating, cooling and condensing equipment in industrial processes where hydrochloric acid, hydrobromic acid and bromine are handled. The Republic Steel Corporation reports advances in the production of tinplate by the cold reduction process. The Inland Steel Company has found that both carbon and alloy steels can be machined 30 to 50 per cent. faster following the controlled addition of small quantities of lead. A new nickel-copper high tensile steel has been introduced by the Youngstown Steel and Tube Company, and General Motors Corporation have a new quick process malleable iron which allows a wider use of malleable castings.

Aluminium in Germany

Progress continues to be made in Germany in the substitution of aluminium for heavy metals. From 1934 to 1938 about 92 per cent. of the high tension cables installed in Germany were made of aluminium, whereas from 1927 to 1933 about 66 per cent. were made of copper. The Eloxal plating process has made aluminium useful in many ways in the building industry; very pure metal treated by this process was used for reflectors. The development of arc welding for aluminium and its alloys is said to have more than doubled the use of welding electrodes in 1938. The welding process was applied successfully to the construction of light metal rail cars for the first time in 1938. Expansions in the motor car and aircraft industries also greatly increased the demand for aluminium. Statistics which have been made available show the extent to which the substitution of aluminium for other non-ferrous metals is taking place. In 1933, for instance, the consumption of aluminium in Germany was 17 per cent. of the total for non-ferrous metals which included aluminium, copper, lead, zinc and tin; in 1937 this figure had increased to 36 per cent. Comparing the same years, the consumption of copper decreased from 35 per cent. of the total to 26 per cent.; lead decreased from 17 per cent. to 14 per cent.; zinc from 28 to 23 per cent.; and tin from 3 to 1 per cent.

Output of aluminium in Germany reached 165,700 metric tons in 1938, as compared with 131,600 tons in 1937, and only 19,000 tons in 1933. In other words, in 1938 Germany became the leading aluminium producer in the world, the United States taking second place with an output of only 131,000 metric tons. Despite this increase, however, it was still not possible for Germany to meet all requirements and about 15,000 tons of raw metal and over 4,000 tons of scrap had to be imported. The largest proportion of the imported raw metal came from Canada (5,800 tons) and Switzerland (3,400 tons); Britain was the chief source of scrap (2,300 tons). Increased production in Germany was due in no inconsiderable degree to the completion of the new aluminium plant and smelter at Lunen, Westphalia, which belongs to the Vereinigte Aluminium Werke A.-G. These Lippe Works came into production late in 1938, during which year the Vereinigte Aluminium Werke invested nearly 54 million marks in new plant and equipment, a proportion of which was for the Lippe Works and for the enlargement of the smelter at Toging, as well as the construction of a new plant for producing alumina from clays of German origin.

Welding Research

The second progress report of the Research Committee of the Institute of Welding shows the stage which has been reached in the organisation of a general programme of research on welding after two years of intensive work. It is stated that a considerable amount of work has been undertaken in connection with the weldability of ferrous metals. A list of high tensile steels classified in order of their tensile strength, including the more important steels produced at home and abroad, has been prepared, and separate panels have been formed to investigate the behaviour of steels suitable for use in a structural capacity and those for use in the making of pressure equipment. As a result of this work it is hoped to ascertain the influence of the various alloying elements used in the steels under the conditions of temperature which exist, with a view to allowing specifications to be prepared for limiting the alloying elements or defining the limits of welding procedure necessary to produce satisfactory results with steels of given composition.

A programme of investigation on alloy steels has been drawn up following an exchange of the views of users and producers of steels of this type. Informa-

tion on the welding of cast iron has been prepared by the British Cast Iron Research Association. Questionnaires have been circulated to firms who have adopted cast iron welding, and a summary of the difficulties present in this process at the present time has been prepared. Two further panels have been appointed to deal with problems such as electrodes, welding procedures and oxygen acetylene cutting, because these matters require consideration in addition to the metallurgical problems inherent in the effect of heating and cooling on the physical properties of steel. An advisory panel has also been formed to consider in parallel with other investigations the effect of gas welding and gas cutting for various steels.

Resistance welding appears to be receiving ever wider application in industry. It has made possible the fabrication of many similar and dissimilar metals, forgings and stampings, into finished products of great strength combined with lightness and symmetry, at a speed unequalled by the use of any other process. Notwithstanding its great progress, however, as seen during the last few years, a number of problems still remain unsolved. So far insufficient information is available for a code of practice to be put in hand, so that pressures, currents and timing for a particular purpose can be accurately specified.

Gallium Metal

Germany now claims to possess a world monopoly for the production of gallium, which finds use chiefly as a backing for mirrors and as an alloy for dental fillings, but also has qualities making it especially resistant to chemical influences. It is said that Germany is the only country in the world where comparatively large quantities of the metal are produced upon an industrial basis. The annual production in Germany now amounts to about 50 kilograms, with the price at Rm. 10 per gram. The producers are the Vereinigten Chemischen Fabriken, at Leopoldshall, in the province of Anhalt, which is not very far from the Mansfeld copper mines—the chief domestic source of sundry minor smelter by-products of which gallium is only one. In the United States zinc residues were used as the source of production of gallium on a laboratory scale; the ashes from certain types of coal were investigated in England, but only in Germany has extraction reached a fairly substantial scale.

Pouring Temperature and Heat Treatment

THE effect of a change in pouring temperature receives attention in some notes on the heat treatment of non-ferrous metals and alloys which W. E. Barker contributes to the July issue of *Heat Treating and Forging*. It is pointed out that high pouring temperature in general permits excessive grain growth in the alloy during the period of cooling in the mould. The lengthened time of cooling also permits undue segregation of impurities in the metal at the grain boundaries, and the result is a lowering of the tensile strength and ductility of metal which has been poured at a high temperature as contrasted with the better physical properties obtained when metal is poured at a lower temperature.

In obtaining the maximum physical properties it is necessary to work in a temperature range where small variations bring about considerable effects, and therefore close temperature control—which can be obtained only by the use of proper pyrometers—is necessary. Where castings of a similar nature are required the most suitable casting temperature must be found by experiment. The internal structure of the cast is dependent upon the temperature at which the alloy is poured and the speed at which cooling takes place. A combination of high casting temperature with slow cooling results in a casting possessing the minimum physical properties, or, in other words, a casting of poor quality. If the correct casting temperature is employed and rapid cooling is secured by the introduction of chills, improved physical properties are obtained. Gunmetals which have been cast under ideal conditions usually respond with an improvement in physical properties if subjected to a definite temperature—governed somewhat by the composition—for a calculated period of time. If, however, the grain structure in the original cast is not of the correct type, owing to incorrect pouring temperature or incorrect cooling conditions, the casting will benefit very little from the annealing operation. To remedy this the casting should be remelted and recast.

The upper limit to which gunmetal can be heated with safety and handled in the hot state is about 500° C. Temperatures much above this point produce a rapid loss in tensile strength, and if sufficiently high—say 800 to 900° C.—the loss of strength is so marked that a blow from a hammer is quite sufficient to fracture a large casting. It is because of this property of " hot shortness " that it is not commercially possible to produce rods or sheets of gunmetal composition by the use of hot fabrication processes such as extrusion or hot rolling.

Constitution of Nickel-Iron Alloys

A recent report from the University of Wales (*Philosophical Magazine*, 1939, *27*, 614) relates to a study of the alpha and gamma phases of the nickel-iron equilibrium diagram and covers investigation at temperatures not exceeding 1,000° C. The alloys were examined by X-ray methods in powder form, a special type of camera being devised for the purpose. The alloys used contained up to about 60 per cent. of nickel, and they were initially prepared in ingot form in two conditions of heat treatment, viz., after annealing for 12 hours at 1,000° C. and water quenching, and after annealing for 19 hours at 1,000° C. and cooling to room temperature over an interval of 39 days. Powder samples from these ingots were then subjected to varying forms of heat treatment and the location of boundaries was studied. As a result of their work, E. A. Owen and A. H. Sully have proposed an equilibrium diagram in which the alpha boundary is considered to be fairly definitely established, but they are of opinion that it may be necessary to move the gamma boundary further towards the nickel end of the diagram.

The results put forward vary from previous diagrams in at least two respects. First, the alpha boundary shows a maximum solubility of nickel in iron at about 400° C., with solubility gradually decreasing at lower temperatures, and secondly, the slope of the gamma boundary below 500° C. is smaller than in any other diagrams proposed, that is, the increase in solubility of iron in nickel with rise of temperature is greater than that previously found.

OXIDE FILMS ON ALUMINIUM*

Some Physical Characteristics

By
N. D. PULLEN

THE fact that the surface of a piece of aluminium becomes covered with a relatively thick oxide film when immersed as an anode in a suitable electrolyte under an applied E.M.F. is well known. It is also well known that the colour, texture, etc., of the film varies depending upon the particular electrolyte and conditions used. It is the object of this paper to deal with one or two of the chief physical characteristics of such films and the extent of the variations which have been found.

The composition of the film has been the subject of several papers and the rather contradictory views expressed indicate that the problem is more complex than it appears. Part of the trouble probably lies in the looseness of expression, such as, for instance, the term γ alumina, which might be an oxide or a hydrate. It might be mentioned here that there are four different and well-defined aluminium hydrates, the α and β monohydrates, and the a and β trihydrates; there are also the recognised crystalline oxides, the α and the γ oxide. The former oxide is formed at temperatures over about 900° C., but is stable at ordinary temperatures. The γ oxide is the more usual form and is that obtained on the surface of molten aluminium. The fact that these different forms of alumina are known to exist does not simplify matters, particularly as, in addition to the recognised ones, very many more have at various times been claimed.

As a part of certain research work undertaken at Warrington an investigation was made into the structure and composition of films produced in the three main electrolytes, i.e., chromic, sulphuric and oxalic acids, more particularly with reference to the effect of hydration either by short immersion in boiling water or prolonged immersion in cold.

For this purpose specimens were prepared from superpurity foil held in a framework of aluminium tape. The conditions of treatment were standard, except that the time was prolonged until portions of the foil were completely converted to anodic film.

Structure of the Films by X-Rays

X-ray examination of the as-formed films showed an apparently amorphous state in each case, that is to say, the crystals were too small to give a pattern. Nor was it possible to confirm the presence of the anhydrous γ oxide. There is some evidence to show that chromic acid films as formed, although showing no structure by X-rays, are practically anhydrous alumina, while the anodic films normally prepared in oxalic acid and sulphuric acid contain approximately one molecule water per molecule of Al_2O_3. The films are, however, hygroscopic and of variable composition. When strongly heated to temperature of the order of 600° C., a strong γ—Al_2O_3 pattern can be obtained from these films.

After boiling in distilled water a marked change takes place in both chromic and oxalic films, since X-rays now show a distinct crystalline structure; with sulphuric films, however, there is little difference in the diffraction patterns taken before and after boiling and a much more drastic treatment is necessary before it becomes evident that some change has occurred.

On comparing these patterns with known and calculated patterns for α and γ Al_2O_3, it was evident that they did not agree with either, but they were found to agree with patterns given by Edwards and Tosterud, which they claim to be a monohydrate.

If such films are ignited and the loss in weight calculated as water, results are obtained which correspond to a dihydrate form, although there is some doubt as to the existence of this form. It was at one time claimed that bauxite, the naturally occurring form of alumina, was an aluminium dihydrate, but opinion now regards this mineral as being usually a mixture of the trihydrate and monohydrate.

These results were confirmed by the chemical analysis of films produced in pure chromic acid solution (3 per cent.) since, beyond aluminium oxide and water, nothing was found except a small quantity of a chromium compound equivalent to rather less than 0.1 per cent. It is suggested therefore that this film, when boiled, consists of α monohydrate plus an extra molecule of water held in the lattice, this water being contaminated with small quantities of chromium.

Similar results were obtained with oxalic and sulphuric acid films except that the degree of contamination was much higher. Oxalic acid films appear to contain about 3 per cent oxalic acid and sulphuric films about 13 per cent. SO_3, both probably present as adsorbed basic compounds.

These remarks apply to freshly formed films after boiling in distilled water. Further work is now in hand on the composition of films as formed, but we are experiencing some difficulty in washing away the last traces of adhering electrolyte without altering the crystalline structure.

Flexibility of Anodic Films

The question of the flexibility of anodic films is one which frequently crops up, particularly in connection with the treatment of material which required subsequent deformation, such as spinning, bending or pressing, and it was with the object of investigating the extent to which anodically treated aluminium sheet could be bent without damage to the film that certain tests were put in hand. The principle of the tests was the measurement of the minimum radius of curvature at which crazing (or cracking) of the film just took place and a special former has been designed to do this. It was possible to show, as would logically be expected, that the apparent flexibility of anodic films diminished rapidly with increasing film thickness, the variation being exponential in form and not linear. Thin films thus can withstand a greater degree of bending than thick, the effect being partly due to the obvious fact that the outer layers of a thick film have to stretch more when the treated metal sample is bent than those of thin films. The apparent flexibility also varies with gauge of metal; given films being more flexible on thin gauge metal than on thick, and this factor has also to be considered in conjunction with the type of film itself and its film thickness.

The variation of the apparent flexibility of a particular film type, as measured by the radius of curvature at the bend where crazing just occurs, can be related to the film thickness by a useful empirical relationship which can serve as a measure for comparing the flexibility of the various films This may be expressed in the form:

$$\text{Flexibility Index} = R^{\text{Log } x}$$

where R = radius of curvature and x = film thickness in inches. This relationship holds well for a wide range of film thicknesses on metal of the same gauge. If logarithms to the base 10 are used, this index is readily shown to be the film thickness which would theoretically craze when bent round a radius of 10 inches, using a standard gauge of metal, and thus provides a useful measure for comparing the flexibility of various films.

It can also be shown that the use of alternating, where possible, in place of direct current, as well as somewhat higher bath temperatures, favours more flexible films. Of

* From a paper read before the Electrodepositors' Technical Society.

those films tested, comparing equal thickness, the oxalic A.C. and chromic acid films were the most flexible, while sulphuric acid and oxalic acid D.C. films the least flexible.

The actual amount of stretching or elongation which anodic films can withstand is difficult to measure directly, but it is about 0.3—0.4 per cent. This value may be obtained both by direct measurement under special conditions and by indirect means from the radius of curvature required to crack the film using the relationship $E = \frac{d}{2R}$ (E = elongation, d = gauge of metal, R = radius of curvature at bend). This relationship may also be used to compare anodic films on metal of different gauges.

Hardness and flexibility are generally incompatible and films treated for maximum hardness have poor flexibility and *vice versa*. Actually, the " hardness " of an anodic film has not yet been adequately defined, and practically all methods of its measurement are really wear-resistance or abrasion resistance methods. Since anodic films are usually much harder than the aluminium base, normal indentation methods of hardness measurement are useless or misleading and scratch methods are also generally unsatisfactory, the tendency being to crush the film and furrow the underlying metal.

The wear-resistance methods employed for hardness testing of anodic films vary greatly. They may utilise the abrasive power of small grinding wheels, or of a sand jet, although modified scratch methods are also used. In all cases the results are more or less purely empirical and only useful for comparative purposes. It is actually possible to prepare films so hard that they can only be scratched with difficulty, if at all, by a steel point.

The use of direct current, low treatment temperatures, high electrolyte concentration and moderately thick films favour maximum hardness. Cold sulphuric acid and oxalic acid electrolytes normally give the hardest films.

With increasing use of anodised aluminium for electrical purposes, knowledge of the electrical breakdown characteristics of anodic films becomes of more importance.

Thick anodic films have, as would be expected, higher electrical breakdown voltage than thin, and over the normal range of film thickness, viz., .005—.02 mm., the variation is practically linear, being of the general form:—Breakdown voltage = $A + bx$, where A and b are constants and x is the film thickness (in thousandths of a mm.) For very thin films, however, the linear relationship between breakdown voltage and film thickness does not hold, becoming exponential in form. For small values of x, A in the above equation should be replaced by the expression $Ae^{\frac{1}{x}}$ which approximates in value to A as x increases, the effect being that the breakdown voltage increases rapidly for small increases in film thickness when the total thickness is small (less than about .005 mm.).

The value for the breakdown voltage of films is influenced to some extent by the nature of the film and its mode of treatment and water content, but there is not a great deal of difference between anodic films of the same thickness and similar after-treatments. Breakdown values of over 1,000 volts for individual films are readily obtained on plain films. The breakdown voltage per mm. for normal films of average film thickness is of the order of 30,000 volts and by special impregnation, *e.g.*, after treatments with special oils or resins etc., this figure can be greatly increased.

Anodised aluminium has the important advantages from an electrical point of view of a light compact insulation which is resistant to heat, up to almost the melting point of aluminium itself.

Electro-Forming With Iron

The New Ekko Process

IN *Industrial and Engineering Chemistry* (News Edition) of July 20, 1939, an interesting illustrated account is given of the process evolved by the U.S. Rubber Co., of Detroit, for electroplating or -forming in iron, which is the subject of several pending patent applications. It is essentially a method of duplicating or preparing moulds, patterns, copies, and exact replicas of a great variety of objects. In some cases where it is desired to make exact duplicates of existing moulds a pattern is prepared from the mould, preferably of suitable metal such as Cerrobase—a bismuth-lead alloy of m.p. 255° F. non-shrinking—manufactured by the Cerro de Pasco Copper Corporation. This is then plated with iron. The thickness of the deposited iron depends on the varying needs and conditions, but very often it need not be more than 0.375 in., and this takes two weeks for deposition, a period which compares favourably with that required for engraving a complicated design, especially if it be remembered that several articles can be placed in the plating tank at once.

The iron solution which has been developed by the company has unusually good throwing power so that models or patterns of very irregular shape can be dealt with, though very deep recesses may need special treatment. The method is specially effective in the reproduction of fine detail, and the deposited metal follows the pattern so perfectly that it has been possible, for example, to make an iron phonograph record of high quality musical reproduction; or a diffraction grating with 7,400 lines to the inch. It is clear, of course, that intricacy of detail has little bearing on the cost in a process of this kind. The qualities of the deposited iron as to hardness, tensile strength, purity, heat treatment, hardening, etc., are described. Its high heat conductivity is a valuable characteristic where rapid heat transfer is desired. Various methods of backing or framing the mould for use may be applied, and different materials used for this purpose, such as Babbit metal, aluminium, plaster of paris, etc.

The method was originally intended for the provision of motor tyre moulds, and the method in this case is briefly as follows: from the standard tyre mould which it is desired to duplicate a rubber pattern is prepared and is rendered conductive by dusting over with graphite. It is then placed in the electro-forming tank, and when the desired metal thickness has been formed on the pattern it is removed and separated from the rubber mould, cleaned and smoothed, and finally welded into a heavy backing or case ready for use. The method has now been extended to several other uses.

Probably its most remarkable application is in the production of dies or moulds in which a photographic likeness can be transferred to iron. This involves the application of an intermediate photographic process recently developed by Ford Ceramic Arts Inc., of Columbus, Ohio, whereby it is possible to transform a photograph or negative into a three-dimensional relief where the shadows in the original picture will appear as depressions while the high lights will be raised. From the plaster casts produced iron moulds or plates can be made in which the photographic likeness of the original can be obtained. It is not, however, limited to photographs of people or scenes but can be used to transfer designs in black and white to a corresponding relief and thence to a mould or embossing plate. Owing to the inclusion of the photographic stage in the operations there is no difficulty presented in regard to enlargement or reduction, and the same design may be produced in a whole series of different sizes, as in a set of artistically designed plates or dishes of varying diameter.

Lanthanum and Its Compounds

Production and Application

IN the production of cerium and thorium or their oxides from monazite sand, lanthanum oxide is also produced in fairly considerable amount but hitherto there appears to have been insufficient commercial demand for this particular rare metal either as such or in the form of oxide or other compounds. About a year ago the Auergesellschaft, of Berlin, announced a prize competition, in which the prizes would amount to about 10,000 Rm., one of the objects of which was to discover suitable commercial uses for lanthanum and its oxide. The competition closed in June last but the results have not yet been published. The German firm in question, who, among other things, are makers of the well-known Welsbach lamps, have drawn attention to a few small uses of this rare metal, including its possible use in alloys (*e.g.*, Caneri's work in this field), but a much wider industrial utilisation is desired. At the same time Weibke (in *Zeit. f. Elektrochem.*, July, 1939) has described a new method for the production of lanthanum by electrolysis of the chloride, to which further reference is made herein. The Auer Company would prefer that the new uses should be for lanthanum or its oxide in conjunction with praesodymium and neodymium or oxides, with which it is usually associated, as this would avoid final separation of the lanthanum, but new uses for the latter alone would be welcomed.

Among the applications already found for this material may be mentioned, as the most important, its inclusion as a constituent in ceramic glazes, optical glasses, opacifiers, and for weighting silk and rayon. Some work has been done on the addition of lanthanum compounds to the carbons of arc lamps to improve the lighting efficiency, but the amounts so used are very small. A certain amount of research has also been carried out with lanthanum compounds in the biological field, but from the industrial point of view probably the greatest interest would be the use of lanthanum or compounds in alloys or as catalytic agents, as in the production of hydrocyanic acid from carbon monoxide and ammonia, or in the decomposition of alcohols. In B.P. No. 339,961 Freedman has proposed the use of lanthanum oxide as a "getter" (adsorbent of residual gas) in radio valves and the like. Caneri's work on lanthanum in alloys with lead, tin, thallium, silver, copper, or gold (*Metallurgia* (Ital.), 1931, *23*, 803-23) was of some interest and promise, but further study in this direction is desirable. Combined with aluminium and/or other metals it has been used for pistons and cylinders, and amalgams have been prepared with mercury. A large number of compounds of lanthanum, both organic and inorganic, have also been prepared, but the field of use so far has been very limited.

In his paper on the preparation of the metal from lanthanum chloride by electrolysis, Weibke states that he is mainly interested in its solubility in aluminium and magnesium and the effect thereof on the hardness of alloys of these metals. Various methods have been tried for the production of metals from cerium ores, such as Wohler's potassium method improved by Zintl and Neumayr, and the mercury amalgam process used by Meintz and others. But these present certain difficulties, and electrolysis of the pure lanthanum chloride has been adopted in the present case. The chloride was first dissolved in hydrochloric acid with addition of ammonium chloride, the solution evaporated, the residue ground to powder, and most of the ammonium chloride driven off by heating. A suitable melt for electrolysis was formed by adding 3.75 g. of potassium chloride and 0.25 g. of calcium fluoride per gram of lanthanum chloride; or, in other words, the mixture contained 27.4 per cent. of lanthanum chloride, 68.0 per cent. of potassium chloride, and 4.6 per cent. calcium fluoride. This was heated in a furnace at a temperature of 980° to 1,010° C. and electrolysed. From a series of tests, using current densities of 4 or 7 amps. per sq. centimetre respectively, temperatures varying between the narrow limits above mentioned, and amp.-hours of varying length, it was concluded that the optimum conditions are 7A/cm.^{2}, 1,000° temperature and time 25 amp.-hours. The lanthanum was of 99.86 per cent. purity in an assay with hydrochloric acid.

Some Recent Metallurgical Patents

Extracting Metals

Metals, *e.g.*, aluminium, beryllium, cadmium, calcium, barium, strontium, magnesium, copper, tin, sodium, potassium, and zinc are recovered from dilute liquid metal amalgams by cooling the latter to a temperature sufficiently low to precipitate a solid concentrated amalgam which is separated from the liquid mercury. The concentrated amalgam may be used as a reducing agent, may be decomposed by heat, and/or, in case of amalgams of alkali-metals, by treatment with substances such as magnesium or alkaline-earth metals as described in Specification 505,097, the mixture being preferably rendered liquid by the addition of molten alkali metal, and the alkaline earth or other treating metal being recovered for further use by distillation of the mercury. The dilute amalgam may be produced by the electrolysis of a metallic salt using a cathode of mercury as in Specification 491,879, or of an amalgam which may be such as to provide a dilute mixed amalgam. The electrolysis may be carried out at a temperature of 60° to 80° C. or at higher temperatures produced by operating the cell under pressure. The amalgam so produced may be cooled to 10° to 30° C. and the separation of the concentrated amalgam is effected by filtration followed by pressing, the mercury being returned for use as a cathode. (See Specification 505,111 to Du Pont de Nemours and Co., E.I.)

Alloys

A pre-alloy, 4 to 12 per cent. of which may be mixed with magnesium or its alloys, consists of 33 to 40 per cent. of aluminium, 23.5 to 16.5 per cent. of zinc, 17.5 to 14.5 per cent. of copper, 3 to 6 per cent. of manganese, 1 to 3 per cent. of nickel, 6 to 4 per cent. of cobalt, 0.5 to 0.9 per cent. of chromium, 0.5 to 0.1 per cent. of molybdenum, and 15 per cent. of magnesium. (See Specification 505,456 to F. Christen.)

Alloys : Heat-Treatment

Nitrogen-containing high chromium iron alloys containing 20 to 35 per cent. of chromium are heat-treated by heating at 1,050° to 1,300° C. for a suitable period, *e.g.*, ½ to 2 hours and then rapidly cooling or quenching. The alloy preferably contains 22.5 to 28.0 per cent. of chromium and the nitrogen content is 1-50th to 1-200th, and preferably 1-100th, of the chromium content. The alloy may also contain 0.5 to 2.0 per cent. of nickel. The alloy may be prepared by melting commercial ferro-chromium which has been treated in small batches at 1,200° to 1,400° C. for about 2 hours in an atmosphere of nitrogen melted and cast, with non-nitrogen treated ferro-chromium and low carbon steel and/or commercially pure iron. The resulting alloy is deoxidised with manganese before casting. (See Specification 505,251 to E. W. Colbeck and Imperial Chemical Industries, Ltd.)

Extracting Alkali-Metals

Alkali-metals, *e.g.*, sodium, are produced by electrolysing an aqueous solution of an alkali-metal salt, *e.g.*, sodium carbonate or halide, with a mercury cathode, distilling the resulting amalgam to produce an alkali-metal containing a small amount of mercury as impurity, subjecting the impure alkali-metal at a temperature above its melting point to the action of an alkaline-earth metal (including magnesium) and separating, *e.g.*, by filtering, settling, or centrifuging, solid mercury-containing material from the melt. The electrolysis may be carried out as described in Specification 491,879, the treatment with alkaline earth metal may take place in the presence of alkali-metal and the distillation may be carried out under reduced pressure and in two stages, the first of which is such as to yield as residue a solid amalgam. The alkaline earth metal should be in finely-divided form, such as that produced by cooling to 100° to 120° C. a solution of the metal in alkali-metal made at 500° to 700° C. the precipitated metal being used either after filtering or in the form of a mixture with the alkali-metal. The alkaline earth metal should be agitated for 1 to 10 minutes with the dilute amalgam at 200° to 300° C. and in amount equal to 3 to 5 times the amount of mercury present, and, if desired, in the presence of alkali metal in such proportions that the mixture contains 50 to 75 per cent. of alkali metal, the mixture being then cooled to 100° to 200° C. and the alkali-metal obtained as filtrate. The precipitate will consist of a mixture of alkaline-earth metal, mercury and alkali-metal, which after distillation of the mercury, may be used for the treatment of further quantities of alkali-metal amalgams. (See Specification 505,112 to Du Pont de Nemours and Co., E.I.)

Treating Ores

Materials containing sulphide or iron, *e.g.*, mattes, flotation concentrates comprising pyrites or pyrrhotite, etc.., are reacted in suspension with sulphur dioxide at a temperature above the melting point of the sulphide whereby to produce iron oxide which is collected in solid state or as a molten bath. Thus, the finely divided sulphide material may be dispersed in a stream of oxidising gas, preferably oxygen or oxygen-enriched air, the amount of oxygen supplied being sufficient for oxidation of only part of the sulphur of the sulphide, and then in the absence of free oxygen, the sulphur dioxide formed or previously contained in the gas is reacted with the molten sulphide. Melting of the sulphide may be started by the heat of oxidation of the part of the sulphur, but the oxidising gas and the sulphide material are preferably preheated, and the temperature may also be regulated by burning powdered coal, sulphur, carbon monoxide, producer or fuel gas, etc. When the sulphur dioxide reacting with the sulphide is produced separately outside the reaction tower, it and the sulphide material must be preheated. As more particularly described, crushed pyrites or pyrrhotite and additional combustible material are injected with the oxidising gas into the furnace. When the iron oxide is to be collected as a molten bath, the burners are preferably directed at a right or oblique angle thereto, or at the furnace wall near to the bath. The fused iron oxide may be granulated by air, or alternatively after cooling, may be sintered. If the bath contains, say, nickel or copper sulphides, it is allowed to solidify, crushed, and subjected to flotation. If the more valuable ores contain silica, slag-producing additions, *e.g.*, quartz, lime, fluorspar may be added to the bath or to the ore, whereby the more valuable sulphides are easily separated in matte form. If the ore contains considerable amounts of sulphides of, say, copper and nickel, the roasting is adjusted so that incomplete oxidation of the iron sulphide occurs. The matte of iron, copper, nickel, etc., so formed, is crushed and subjected in the above described manner to incomplete roasting in combination with smelting. (See Specification 505,631 to T. R. Haglund.)

Heat-Treating Metals and Alloys

Metals or alloys, the atoms of which are arranged in a cubic face-centred lattice, are rendered magnetically anisotropic by rolling several times alternately in two directions in the same plane perpendicular to each other. The material, which is preferably an iron-nickel alloy having 30 to 60 per cent. of nickel, is heated after rolling to a temperature at which recrystallisation but no destruction of the texture occurs, *i.e.*, 600° to 800° C. (See Specification 504,974 to Siemens and Halske Akt.-Ges.)

Quaternary Lead Alloys

Quaternary lead alloys, particularly for cable sheathing and fluid conduits, consist of lead with less than 0.05 per cent. of phosphorus, less than 0.15 per cent. of calcium, and less than 1 per cent. of tin, copper, or zinc. The phosphorus may be introduced as a phosphide of tin, copper, or zinc. (See Specification 505,555 to H. G. C. Fairweather (Compagnie Generale d'Electricité.)

Copper Alloys

A welding electrode or rigid make-and-break switch contact is made of a copper alloy containing 0.1 to 10 per cent. of cadmium, 0.1 to 5 per cent. of chromium, and 0.1 to 5 per cent. of one or more of the metals iron, cobalt, and nickel, with or without gold or silver or both, and with or without a total of 0.1 to 5 per cent. of one or more of the elements of beryllium, calcium, boron, aluminium, silicon, zinc, phosphorus, magnesium, molybdenum, tungsten, and tin. The alloys may be made by sintering a pressed mixture of the powdered constituents, or by alloying a pre-alloy of chromium and an iron group metal with the remaining constituents either by sintering or melting, or by coating powdered chromium with copper and sintering this with the remaining constituents. (See Specification 505,017 to Naamlooze Vennootschap-Molybdenum Co.)

Alloys for Permanent Magnets

Permanent magnets are made from an alloy containing iron with the usual impurities and 0.7 to 1.6 per cent. of carbon, 2.0 to 10 per cent. of chromium, and 0.1 to 3.9 per cent. of aluminium with or without one or more of the following; up to 8 per cent. of tungsten, up to 4 per cent. of molybdenum, up to 38 per cent. of cobalt, up to 2.5 per cent. of manganese, and 0.1 to 2 per cent. of nickel. The alloys especially when manganese is present, are hardened by rapid quenching and when nickel is present, the aluminium content does not exceed 2.4 per cent. Moreover, up to 2.5 per cent. in all of one or more of silicon, titanium, magnesium, and calcium may be present, the quantity of the said addition and aluminium together not exceeding 5 per cent. Up to 1.5 per cent. of the nickel content may be replaced by an equal weight of copper. (See Specification 505,711 to Deutsche Edelstahlwerke Akt.-Ges.)

Alloys of High Percussion Strength

An alloy of high percussion strength suitable for bearing-metals consists of 80 to 86 per cent. of lead as well as tin, antimony, and a small quantity of cadmium or arsenic or both, the content of antimony, arsenic, and cadmium being at most equal to, and preferably not less than, the tin content. In an example, 6 to 10 per cent. of tin and 6 to 10 per cent. of antimony plus arsenic plus cadmium are present and in a preferred range 7 to 9 per cent. of tin, 7 to 9 per cent. of antimony, arsenic and cadmium, of which 6 to 7 per cent. are of antimony, 0.3 to 1 per cent. of arsenic and 0.7 to 1.5 per cent. of cadmium. If desired, up to 2 per cent. of copper may be present. Austrian Specifications 130,903 and 135,895 and U.S.A. Specification 1,754,364, as well as an alloy comprising 78.5 per cent. of lead, 1 per cent. of arsenic, 1.5 per cent. of copper, 10 per cent. of antimony, and 8 per cent. of tin, are referred to. (See Specification 505,146 to P. Kemp.)

Metallurgical Section

October 7, 1939

IRON ORE

Germany's Precarious Position in Sweden and the Saar

By
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ACCORDING to the figures issued by the Ministry of Economic Warfare during the week ended September 26 over 70,000 tons of goods were detained and intercepted by the British Contraband Control. Included in this total were 23,150 tons of iron ore. The figure for iron ore for a previous week was 26,350 tons, so that it is probable that since the outbreak of war nearly 100,000 tons of iron ore have been seized.

To many people, concentrating on the highlights of war, this may be of little interest, but its importance in the present struggle should not be missed. Pig-iron which is used for the production of steel is one of the most essential of all the sinews of war, and it is impossible to produce either pig-iron or steel without supplies of iron ore. In regard to supplies of iron ore it is interesting to compare the position of Germany in the present war with her position during 1914-1918. Before 1914 the German frontier passed through the Lorraine-Luxembourg district, in fact this area marked the junction points of the French, German, Belgian and Luxembourg frontiers, and was divided, although very unequally, among those countries. The district is by far the most important iron-ore field in Europe and covers an area of 300,000 acres or about 500 square miles, and the total ore reserves in 1914 were estimated to be over 5,500 million tons. At this time 180,000 acres were in France in the departments of Meuse and Meurthe-et-Moselle, and 106,000 acres were in Germany. At the beginning of the last war the Germans swept across this district and gained almost complete control of practically the whole area, including the iron mines. In normal times prior to 1914 Germany had been able to supply a very large percentage of her demands for iron ore from this field and although the existence of low-grade deposits in other parts of Germany was quite well known, little had been done to develop them. So little value was attached to these other deposits that over 10½ million tons of ore were imported in 1911, and nearly 6 million tons were imported during the first six months of 1914. As a result of success in the field in 1914 Germany was able to supply nearly all her demands for iron-ore and the amounts which required to be imported were relatively small, although it may be noted that the total tonnage of ore smelted fell from nearly 36 million in 1913 to 21½ million in 1918.

Large French Reserves

As a result of the Treaty of Versailles not only did France regain her former territory but the western boundary of Germany was pushed so far back that the whole of the Lorraine ore field was included in Eastern France, while even the Saar was mandated to France until by the plebiscite of 1935 it returned to Germany. The acquisition of this province made France the most important iron-ore producing country in Europe and the holder of the largest reserves. Germany, on the other hand, was forced to turn her attention to the low-grade deposits which had previously been neglected. In view of this it is not surprising that the Maginot Line has been built or that French strategy on the Western Front has been to push into German territory and occupy as much as possible of the highly industrialised Saar valley. Thus two purposes are served: the important German industries in that valley are immobilised, and a barrier has been raised against a repetition of the German drive westward over Lorraine.

When the German iron and steel industry was reorganised after 1919 certain difficulties had to be met. A large percentage of the iron-ore demand was met by importing ore from France and from Sweden. At the same time prolonged and, in many cases, expensive efforts were made to develop the low-grade deposits. These deposits occur in four main groups, known as Siegerland, Bavarian, and Baden, Lahn and Dill, and Salzgitter. All of them are low-grade with no very extensive reserves. Their importance can be judged from the fact that in 1933 only 2½ million tons of ore with an average iron content of 30 per cent. were mined. With the tremendous drive for self-sufficiency this figure has mounted steadily until last year it was 11,145,000 tons. A small but welcome addition to the supply was the Erzberg mine in Austria. This mine, which came under German control in 1938, has a reserve of 200 million tons with an average content of 33 per cent. iron. The tonnage of imported ores has also risen from 4½ million tons in 1933 to almost 22 million tons in 1938.

German Low-grade Deposits

The most ambitious attempt to utilise the local low-grade ores was the building of the Reichswerke Hermann Goering for the treatment of the Salzgitter ores. These deposits are said to have a reserve of 1,000 million tons of ore with an average iron content of 30 per cent.

These ores, like the majority of the low-grade German deposits, have a high phosphorus content and can be utilised only by treating the pig-iron by the basic Bessemer process. The coal required is to be obtained from the Ruhr and will be transported through the newly constructed Midland Canal. An annual ore output by deep mining of 20 million tons is aimed at, but at present only open-cut stripping is being employed and the output is said to be about 3½ million tons.

An interesting light on the present position may be obtained from the following table which shows the amounts of iron ore imported into Germany from various countries during the past three years:

Country	Amounts Imported (in metric tons).		
	1936	1937	1938
Sweden	8,248,200	9,083,800	8,992,300
Spain and Spanish Morocco	1,067,700	1,381,600	1,807,100
France	6,859,800	5,739,500	5,056,100
Luxembourg	564,700	1,470,400	1,718,000
Newfoundland	171,400	808,000	1,121,500
Norway	527,300	509,700	1,181,100
Algeria	531,200	724,600	755,500
Greece	182,300	219,100	249,400
Tunis	47,300	13,500	131,000
Switzerland	5,400	67,200	121,000
Belgium	3,600	68,000	57,500
Totals (all sources)	18,469,300	20,620,900	21,927,500
Total consumption (home and foreign)	26,000,000	30,500,000	33,000,000

Taking 1938 as an example, the total iron content of the

home-produced ores may be taken as about 3,700,000 tons, assuming the figure of 32 per cent. iron as the average value of the ores, while the total iron content of the imported ores will be at least 50 per cent. and probably more. So that of the total iron required 75 per cent. must be obtained from imported ores.

Turning now to the countries which supply Germany with her iron-ore requirements in normal times, the two main sources are France and Sweden, which between them furnish over 66 per cent. of the total. Now under the present war conditions how will the supplies be affected? Obviously the first major loss will be the Minette ores from France, but in addition any supplies which have to be transported over seas under the control of Britain and France will also be interrupted. The countries whose supplies will be affected in this way are Spain and Spanish Morocco. Newfoundland, as a member of the British Empire, and Algeria and Tunis, being under French control, will cease supplies. Even allowing for the continued support of the other powers who are not subject to direct economic pressure from Germany, such as Norway, Greece, Switzerland, and Belgium, the total loss of imported ore on the basis of the figures for 1938 will be over 9½ million tons or about 5 million tons of metallic iron, that is, about 34 per cent. of the total iron smelted in the blast furnaces in Germany.

The next question is whether this deficiency can be easily met from other sources. It may be taken for granted that the limit of expansion in the use of internally produced ores must be very near, if, in fact, it has not already been reached. If it is realised that to supply this deficiency over 15 million tons of ore will have to be mined in addition to the already large total of 11 million tons, then the enormous difficulties in this course will be apparent. Also, this assumption takes no account of the fact that the increased blast furnace capacity required to smelt the much larger volumes of low-grade ore and the increased coke consumption would result in an intolerable burden on these industries.

The Swedish Mines

The only remaining large exporter of iron ores to Germany is Sweden. This trade dates back to a period before the last war. The most important iron ore mines in Sweden are those at Kiruna and Gällivare in Swedish Lapland. These two deposits both contain very high-grade iron ore. The Gällivare deposit is in a long hill and the broken ore is transported from the stopes by trucks through horizontal tunnels or hoisted in shafts. The Kiruna ore body is the largest single deposit of high-grade iron ore in the world. It takes the form of a mountain ridge which is almost three miles in length and has been proved to a depth of 8,000 feet below the summit of the ridge. The ore reserves are 1,500 million tons with an average iron content of over 60 per cent. Nearly all the ore is mined in open-cut pits.

The ore from these mines is taken by electric railway either to the port of Narvik on the Atlantic coast of Norway or to Luleå on the north of the Baltic Sea. The Baltic Sea route to Germany is, of course, the safest, but the northern part of the sea is closed by ice for four to five months in the year. The Atlantic route is open all the year but is liable to be interrupted by the British blockade.

It is to these mines then that Germany must look for any additional supplies of iron ore that may be required. The present production is from 10 to 11 million tons a year and it is doubtful if this could be stepped up to an extent sufficient to meet the demands even if the Swedish Company were willing. Relations between Germany and Sweden took a serious turn after the sinking of the Swedish steamer "Gertrud Bratt" by a U-boat on September 25, and it was suggested from Stockholm that the most telling protest would be the cessation of ore supplies to Germany. This threat may never be carried into execution but it is a reminder of the precarious position of Germany in regard to this essential commodity, a commodity which certainly could not be supplied by Russia even as a result of the new Soviet-German pact.

Analysed Metallurgical Samples

Bronze and Cast Iron

Two new analytically standardised samples, which are now ready for issue, Bronze "C" (No. 207) and Cast Iron (No. 206), are announced by the Bureau of Analysed Samples, Ltd.

Bronze "C" (No. 207) has the following percentage analysis: Copper, 86.84; tin, 9.80; zinc, 2.55; nickel, 0.09; lead, 0.41; phosphorus, 0.05; iron, 0.06; antimony, 0.04; arsenic, 0.05; sulphur, 0.06.

The analysis of Cast Iron (No. 206) is:— Total carbon, 2.59; combined carbon, 0.05; silicon, 3.32; manganese, 0.33; sulphur, 0.063; phosphorus, 1.51; titanium, 0.16; chromium, 0.07; nickel, 0.02; vanadium, 0.13; copper, 0.02; arsenic, 0.04.

B.C.S. Bronze "C" (No. 207) corresponds in composition to B.S.I. specification 383, 1930 for 2/10/88 bronze (gunmetal, ingots, and castings). It enables manufacturers and buyers of ingots working to this specification to procure a standard sample for their chemists to check their methods of analysis. This will be especially useful in cases where the percentage of some constituent is on the border line of the specification. The sample has been prepared from very fine turnings from a specially prepared casting and is therefore in a more acceptable form than an earlier standard of a somewhat similar type (Bronze "A").

Cast Iron No. 206 is a sample which was specially prepared to meet the need of an iron high in both phosphorus and silicon and is typical of certain irons manufactured both in the Cleveland district and in the Midlands. In addition to the usual five elements the sample has been analysed for all the likely so-called "minor" elements, as it is frequently useful to have a standard in which all the minor elements have been determined. For instance, these elements are sometimes present in larger quantities than one would suppose and they may have some influence on the determination of the main constituents. In this particular case, the titanium appears to have affected the usual wet oxidation method for sulphur and to have caused some of the sulphur to remain in the insoluble residue.

Both the Bronze and the Iron have been analysed by a number of experienced chemists, including independent analysts and chemists representing well-known manufacturers and users. The certificate of analysis which is supplied with each bottle of standard gives an outline of the methods used by the co-operating chemists and includes certain comparatively new and interesting processes. The standards are issued in bottles containing 25, 50, 100 and 500 grammes, and may be obtained direct from the Bureau of Analysed Samples, Ltd., 3 Wilson Street, Middlesbrough, or through the usual laboratory furnishers.

B.S.S. FOR METAL CONTAINERS

The British Standards Institution has issued a specification for metal containers for food products (No. 866-1939).

The confusion resulting from the multiplicity of sizes of cans used for packing food led to the appointment in 1936 by the Chemical Engineering Industry Committee of a representative committee under the chairmanship of Sir Edgar Jones, K.B.E., to consider the preparation of British Standards for the sizes of metal containers for food products. The schedule provides for a standard series of can sizes for jams, fruits, vegetables, soups, fish, milk, and meat and meat products. It is confined to open top and stud-hole cylindrical cans and to rectangular and oval "drawn" cans used in the fish canning industry. The committee hope that the issue of a recommended British Standard series of can sizes for each particular section of the canning industry will go far towards clarifying the position.

The present issue of the B.S. series has been confined to the cans for home and export trade used by British packers, but it is hoped shortly to arrange an Imperial Conference for the unification of can sizes throughout the Empire.

Current Topics

Etching Reagents and Technique

THE American Society for Testing Materials is issuing a new specification to replace the present one (E.3-36) entitled "Tentative Method of Preparation of Metallographic Specimens." The test of the new specification, now recommended for guidance of workers, presents only those practices which experience has shown to be generally satisfactory in metallography. Those phases of the preparation of metallographic specimens which vary little with the material are discussed collectively, and the special features particularly applicable to one metal and its alloys are given in the section relating to that class of material. The Methods of selection, preparation and mounting of specimens are detailed, and specialised metallographic practice is described with reference to aluminium and aluminium-base alloys, copper and copper alloys, iron, steel, lead, magnesium, nickel, tin, and zinc. Among nickel and nickel alloys there is reference to nickel-copper, nickel-silver, Monel, Inconel and other nickel-chromium-iron alloys. A very useful bibliography of over one hundred references relating to metallographic practice is included. For details of the preparation of photomicrographs and photographic practice generally, workers in this field are referred to the recommended practice given in specification E.2.

Alloy Development

AMONG the outstanding features in the progress of metallurgy during recent years, the development of alloys claims a prominent place. In an interesting article in last month's *Journal of the Franklin Institute*, Dr. A. B. Kinzel outlines some of the most important steps in this development. He points out how, at the end of the last century, with the advent of the metallurgical microscope, thermal analysis, and convenient hardness testing, the development of new alloys changed from an art to a science which has to-day reached a still higher level because of concepts made possible by X-ray analysis. In the wake of X-ray analysis came Dr. Merica's theory of ultramicroscopic precipitation as a hardness-inducing phenomenon. Shortly thereafter Corson hardened copper with silicide precipitation, Dean hardened lead with precipitated antimony, Mudge hardened nickel-copper by precipitated aluminides, and Masing hardened copper by precipitating beryllides. To illustrate how the new understanding of the differing types of alloys has made possible the advance of modern alloying, Dr. Kinzel chooses the copper and silicide story to illustrate the case of the precipitation-type alloy, and the aluminium-silicon alloy, with or without copper, to exemplify the eutectic type.

Special Properties

CERTAIN alloys possessing some singular property are of interest. An alloy of copper, manganese and nickel containing approximately 12 per cent. manganese and 4 per cent. nickel is illustrative. In this alloy constant electrical resistance has been achieved as a function of temperature over the range found in usual living conditions, and in addition the alloy has a low thermoelectric force when coupled with copper. It is used in electrical measuring instruments similar to the meter whose reading determines your monthly electric light bill. Again, an alloy of nickel and iron which contains some 37 per cent. nickel possesses a coefficient of expansion that approaches zero over a limited temperature range, including the one in which we live, and is therefore used for surveyors' tapes, pendulum stems and thermostatic devices. The phenomenon is probably due to the same mechanism as that of the copper-manganese alloy previously mentioned, namely, a perfectly reversible formation and dissociation of intermetallic compounds within the solid solution—what the modern physicist would call "order disorder" variant with temperature. Iso-elastic is another case in point. This is an iron-base alloy with 37 per cent. nickel, 7·5 per cent. chromium and 0.5 per cent. molybdenum having a practically constant modulus as a function of temperature—again over a limited but desirable range and likewise exhibiting extremely low plastic deformation and mechanical hysteresis. It was developed by de Forest for accurate weighing mechanisms similar to those found in the modern butcher's shop. Similarly, alloys of iron, chromium and nickel with manganese, vanadium, silicon or aluminium have been developed.

Deoxidation of Steel

THE science of deoxidising steels so as to avoid undesirable types of inclusions is of comparatively recent origin. Herty has shown that in the initial deoxidation of a steel bath the use of a special alloy of silicon and manganese results in inclusions of just sufficient solubility and viscosity at usual steel bath temperatures so that they readily agglomerate and float out of the bath. The addition of zirconium to eliminate nitrogen from an active part in the final alloy by formation of zirconium nitride is another finding of more recent years. The use of manganese to eliminate iron sulphide by substitution of iron and formation of manganese sulphide is old in the art. It was long thought that steel could not be made without a manganese addition due to the ever-present sulphur. However, Becket has shown that zirconium may replace manganese in this respect, the mechanism being essentially the same. After the steel is taken from the furnace a final deoxidation in the ladle is necessary. Silicon and aluminium are widely used for this purpose. This brings with it a certain danger of inclusion formation, but as a rule the oxygen content is sufficiently low, so that this matter is not serious. However, when large additions of aluminium are used in order to obtain inherently fine-grained steels, the inclusion problem may again become serious. This matter of fine-grained steels is illustrative of more recent developments. It has been found that if a large aluminium addition is made to the steel the tendency for grain growth in the austenitic phase is markedly reduced, the steels so treated being known as inherently fine-grained steels. Vanadium has been used similarly for many years, and without the correlative inclusion problem, but the cost of this element has discouraged its use in the less important alloy steels.

Economic History of Steel

DESCRIBED as the first book to study the all-important steel industry in its various aspects, *The Economic History of Steelmaking*, by D. L. Burn, is published by the Cambridge University Press. In it the author gives a continuous picture of the progress of the industry in all its ramifications, through the critical years of the seventies and eighties, the technical and trading expansions of the 1900's, the extraordinary conditions of the last war years, ending with the Sankey and May Reports, and the hope for the future.

Some Recent Metallurgical Patents

Iron and Chromium Alloys

Alloys of iron and chromium which may be in scrap or other form are treated at a melting temperature with lime and silica and under oxidising conditions whereby chromium is selectively oxidised to form a molten calcium silicochromite, corresponding to the formula $(CaO)_3Cr_2O_3nSiO_2$ where n is less than 3, and a metal containing unoxidised iron, and, if desired, some chromium. The process may be carried out in an electric furnace, a blast furnace or a converter and the lime and silica may be added in the form of lime rock, or other form of calcium carbonate, and quartzite respectively. The oxidising agent employed may be oxygen, carbon dioxide, iron oxide, or iron-ore. Sufficient coke should be present to maintain a concentration of carbon monoxide so as to prevent oxidation of the iron, and the exothermic nature of the reaction may be increased by adding silicon, ferrosilicon, or an oxidising agent such as sodium nitrate. The silicochromite may be used in the manufacture of chromates, bichromates, chromic acid, chromic oxide, and chromic sulphate, or in making nickel-chromium and cobalt-chromium alloys, pure chromium (by reduction with silicon in the presence of additional lime), or alloys of chromium and iron. In the latter case, the silicochromite may contain iron and is granulated, briquetted with a non-carbonaceous reducing agent such as ferrosilicon or silicon, and added to a bath of low-carbon steel. Alloys of iron with up to 3 per cent. and 8 per cent. of chromium, an alloy consisting of 42 per cent. of chromium, 6 per cent. of carbon, 3 per cent. of silicon, and 49 per cent. of iron, and Specification 437,008 are referred to. (See Specification 507,558 to M. J. Udy.)

Beryllium : Alloys

Anhydrous beryllium fluoride, free or substantially free from oxide, is heated with a stoichiometrically corresponding quantity of an element or mixture of elements capable of reducing the fluoride, until reduction is substantially complete. The reducing element or elements may be one or more of the alkali metals, alkaline earth metals, magnesium, aluminium, cerium, silicon, or boron. The reaction mixture may also comprise anhydrous oxide-free or substantially oxide-free alkaline earth metal fluorides or magnesium fluoride. Alkali chlorides or fluorides or alkali-beryllium fluoride may be used as fluoride. Beryllium alloys may be produced by effecting the reaction in the presence of the alloying element or elements, which may be mixed or alloyed, *e.g.*, as a eutectic, with the beryllium, or by introducing into the reaction mixture a compound or compounds reducible by the reducing element or elements the quantity of which then corresponds stoichiometrically with the total amount of such compound or compounds and of the beryllium fluoride. Alloys of beryllium with one or more of the following may be produced, *viz.*, copper, iron, nickel, cobalt, tungsten, molybdenum, chromium, vanadium, titanium, boron, manganese, zinc, silver, tin, thallium, bismuth, lead, cadmium, uranium, lithium, calcium, aluminium, silicon, phosphorus, carbon, gold, platinum. The preparation of the following specific alloys is referred to, *viz.*: beryllium-nickel with 25 per cent. of beryllium; beryllium-copper with 25 or 83 per cent. of beryllium; beryllium-iron with 4.8, 9 or 40 per cent. of beryllium; beryllium-silver with 18 per cent. of beryllium; beryllium-aluminium with 11 to 35 per cent. of beryllium; beryllium-iron-chromium-nickel with 4.75 per cent. of beryllium, 7.75 per cent. of nickel, and 20.5 per cent. of chromium; beryllium-aluminium-lithium with 23.5 per cent. of beryllium and 4.5 per cent. of lithium, or 40 per cent. of beryllium and 40 per cent. of lithium; beryllium-aluminium-copper with 36 per cent. of beryllium and 6 per cent. of copper. (See Specification 505,508 to Seri Holding Soc. Anon.)

Coating Magnesium

A protective and decorative coating is formed upon articles of magnesium or of its alloys by treating with an aqueous solution containing chromic sulphate and an alkali metal chromate or bichromate. The solution preferably contains 1-20 per cent. alkali metal chromate and 0.5-20 per cent. chromic sulphate. Potassium or ammonium chromic sulphate may be the source of the sulphate. Other salts such as sodium or magnesium chloride or sulphate may be present. The article (*e.g.*, a magnesium alloy with 10 per cent. Al, 0.1 per cent. Mn, 0.5 per cent. Si) is cleaned, immersed in the solution (preferably boiling) for 0.5-60 mins., rinsed, and dried. (See Specification 506,836 to Dow Chemical Co.)

Control of Non-Ferrous Metals

Maximum Prices Fixed

THE Control of Non-Ferrous Metals Order, 1939, made by the Minister of Supply in pursuance of the Defence Regulations has been varied to include the following revised schedule of maximum prices fixed for non-ferrous metals :—

Material	Maximum Price (per long ton of 2,240 pounds avoirdupois)
Rough copper, unwrought, in the form of blocks or slabs or in any other form ..	£46 in warehouse.
Refined copper, unwrought, in the form of ingot bars, ingots, bars, or in any other form ..	£49 10s. in warehouse.
Electrolytic copper, unwrought, in the form of wire bars, ingot bars, ingots, or bars, or in any other form	£51 c.i.f. United Kingdom ports.
Copper billets	£55 c.i.f. United Kingdom ports.
Copper cakes	£51 12s. 6d. c.i.f. United Kingdom ports.
Copper cathodes	£50 10s. c.i.f. United Kingdom ports.
Copper wire rods	£55 delivered buyer's premises.
Good soft pig lead (foreign) ..	£16 12s. 6d. ex ship (duty for buyer's account).
Empire lead	£17 ex ship.
Good soft pig lead (foreign) ..	£17 5s. ex warehouse (duty for buyer's account).
Empire lead	£17 12s. 6d. ex warehouse.
G.O.B. spelter (foreign) ..	£15 ex ship London (duty for buyer's account).
G.O.B. spelter (foreign) ..	£15 12s. 6d. ex warehouse (duty for buyer's account).
Empire zinc	£17 5s. ex ship London.
Empire zinc (including domestic zinc)	£17 17s. 6d. ex warehouse.
Domestic zinc	£17 5s. f.o.r. Swansea, Avonmouth.
High grade zinc	£18 c.i.f. United Kingdom ports.
High grade zinc	£18 12s. 6d. ex warehouse.
Zinc sulphide	£56 ex works.
Lithopone, 28 to 30 per cent.	£15 10s. delivered buyer's premises.
Lithopone, 60 per cent. ..	£29 delivered buyer's premises.
Zinc sheets (No. 10 zinc gauge and thicker)	£29 ex works.
Rolled zinc (boiler plates) ..	£27 ex works.
Hard spelter and dross ..	£11 5s. delivered buyer's premises.
Zinc dust	£51 f.o.r. works.
Flux skimmings	1 shilling per unit f.o.r. works.
Zinc oxide (Red Seal)	£19 10s. delivered buyer's premises.
Zinc oxide (White Seal) ..	£23 10s. delivered buyer's premises.
Zinc oxide (Green Seal) ..	£22 10s. delivered buyer's premises.

The Order specifies that where any of the above prices do not include cost of delivery to buyer's premises, the seller may add to the price any cost reasonably incurred by him in delivery to buyer's premises from the point specified in the statement of such price. Where metal quoted above in terms of ex ship London is delivered at buyer's request c.i.f. another United Kingdom port, the customary premium may be added to the price. The maximum prices are exclusive of any duty in the cases where duty is stated in the Schedule to be for buyer's account, and inclusive of any duty in other cases.

Metallurgical Section

November 4, 1939

HASTENING THE CONSTRUCTION OF MECHANICAL FURNACES

Points from American Practice

By
C. C. DOWNIE

SHOULD the present emergency conditions prevail for any very protracted period of time, every effort will probably be made to construct mechanical furnaces as rapidly as possible to meet the demands of the chemical and metallurgical industries. A point worth considering, therefore, is what is probably the most outstanding feature in the American system of setting up these hearths: the effort to economise in time and floor-space.

Furnace construction differs very materially from that of most other mechanical products, since contraction and expansion features have to be considered in conjunction with the refractories used, a condition that offers little latitude for hasty working. Even the tie-rods, sections for door-jambs, flue-fittings, shoes, etc., have all to be made with due allowance for variations affecting the accompanying brickwork. The making of practically "all-metal" sections nowadays follows the established continuous process adopted in the motor-car factory. Sheets, rods and bars are cut to rough shape, with the assistance of different modern welding devices and stamping and forging presses, after which the respective metal products are immediately lifted from the floor by means of small portable cranes, and transferred, according to their weight, to continuous belt or chain conveyors. The latter may take the form of overhead conveyors for the lighter sections, while endless belt conveyors made of stainless steel, or similar metal, are used for heavier articles. The belts usually operate at about three feet above ground level, and allow a batch of attendants to apply portable drills, grinders, and milling devices directly as in motor-car manufacture. As the conveyor lines have to cross one another at certain points, loops are made depending on the size of the article suspended, but a vast amount of floor space can thus be economised.

Intersecting Conveyor Lines

Not a few other attempts at rapid furnace building, following the Ford system, failed because the conveyor lines occupied too much space, but where intersecting lines of conveyors are employed, the maximum number of operatives is engaged in the smallest possible space. All the smaller parts which make up the furnace, such as flanges which have to be reamed out and bolted, buck-stays which require pressing, etc., are handled on the upper conveyor, as these can easily pass over the loop. The larger sections are allocated to the lower conveyor, whilst the plates and heavy metal are run along the endless steel belt.

Bolts, nuts, washers, pins, and the smallest units are run along the aisles by small battery-driven vehicles, and dumped at points convenient to the conveyor lines. Although each finished section is fully scrutinised and examined by inspectors, it is considered essential to check the consumption of these small units, and all broken or bent ones are counted and returned. Thus little danger of imperfectly bolted-up parts can arise, which in the earlier days of mass-production almost led to its undoing. Each operative is supplied with a fixed number in excess of that actually necessary, and has to account for all defective or impaired units before the next shift. Where the furnace requires a tilting device, this complete unit is generally assembled in a matter of minutes.

Gas and oil pipe-lines are bent, staggered, the ends screwed and milled, and finally assembled on the steel belt conveyor. The pipes after being cut off to the desired dimensions are usually suspended by hooks connected about half-way down the body of the metal, and further supported by coiled chains, which act in much the same capacity as a sailor's knot.

Piece-work and Time-work

It is but rarely that one operative is allowed to carry out any one treatment, and at least two are considered necessary in case the continuous work becomes to fatiguing. Probably the most serious obstable to the whole system is when anything goes wrong with the conveyors. Although the best selected sprocket-wheels are used to ensure a firm grip on the chain links, the hasty dragging of different sections from side to side, to meet the methods of the piece-worker, not infrequently results in a breakdown. As the wages of the piece-rate workers depend on continuous operation, practically all responsible men make themselves conversant with rapid repair methods, and when the breakdown arises a regular host of operatives descends from all quarters upon the defective conveyor, and sets it going again. It is doubtful whether this conveyor system would be a success with time workers, at least, so far as furnace construction is concerned, although it has been employed in lighter productions.

As regards wooden patterns, standard makes of arches for furnace roofs, doors, etc., are fitted with the desired class of bricks, namely, scone bricks, "skews," and similar refractory blocks. Mortar is applied, and when sufficiently dry the whole section is placed on a steel belt and removed to where the regular brickwork is added to complete the furnace construction. The patterns are then removed for repeated use on the same system. By working in the foregoing manner, the more tedious work of forming the shapes and designs of brickwork is carried out continuously in different sections, so that no time need be lost.

Only the final construction of laying the hearths is done when stationary, as this operation cannot be speeded-up with safety, as the mortar must be allowed to set and dry completely before transporting. The furnace casing, complete with pipes, shafts, flues, tilting device, and door sections, is prepared ready for the refractories with the assistance of the conveyor system, and all that remains to be done is to add the brickwork, and then await the setting of the mortar. As can be well understood, this last feature has been accorded the closest scrutiny with a view to acquiring the most rapid setting cements, since it is only at the final assembling, followed by firing, that any time is lost, before placing the finished product on the market.

Current Topics

The Institute of Metals

DURING the war the Institute is continuing its activities, other than those of a social character. The headquarters at 4 Grosvenor Gardens, London, S.W.1, remain open, and the joint library and the information department are available to members. These facilities are found particularly valuable by those members who are engaged in the production of munitions. The " Monthly Journal " will continue to publish original papers, and also to provide abstracts, the importance of which becomes more apparent as members find it difficult to obtain access to technical journals. An increase in membership similar to that which occurred from 1914 to 1918 is to be expected during the present emergency.

Magnesite Refractories

METALLURGISTS will find convenient for their use the pamphlet on *Magnesite Refractories*, by Dr. Felix Singer, reprinted from the *British Clayworker*. The growing importance of magnesite in the world's economy is essentially a consequence of the increased demand for sinter magnesite. Not only has the consumption of sinter magnesite been rapidly increasing in the steel industry, its principal field of application, but also new spheres of application have been opened to this material, chiefly due to the introduction of new research methods. The manufacture of the non-ferrous metals, too, employs some of the excellent qualities of sinter magnesite. The pamphlet deals exhaustively with the production, import, and export of magnesite, as well as with the preparation and properties of magnesite bricks. Such bricks have considerable resistance against corroding influences. This is one of their main advantages as compared with fireclay bricks and silica bricks; the sinter magnesite is resistant absolutely against oxidising agents and, up to 1,500° C., also against reducing agents. They stand metal meltings without damage at any temperatures. The resistance against basic meltings exceeds that of almost all other refractory materials since the magnesite is the most strongly basic substance among all materials concerned; and even against acid meltings the resistance is surprisingly good.

Manganese in Steel

REACTION between sodium arsenite and potassium permanganate solutions has been used for the determination of manganese in steels: the manganese is oxidised to permanganate which is titrated in sulphuric acid solution with the arsenite solution, the end-point being the change from pinky or browny green to green. The reaction, however, is not a simple one, but it may be used for assay purposes if the arsenite solution is standardised against pure manganese or a pure manganese compound in the same way. In a report published in a recent issue of the *Chemical Engineering and Mining Review* (Melbourne), E. Crimmins and Dr. J. R. Pound deal with the oxidation in acid solutions. They find that the reaction between arsenites in sulphuric or nitric acid solutions with potassium permanganate gives various products which, though often investigated, are not yet fully understood. The reaction, however, proceeds normally and quantitatively in the presence of osmic acid, potassium iodate, or hydrochloric acid or chlorides plus iodine, and less accurately in the presence of iodine or potassium iodide. Accurate results also are readily obtained by adding ferrous sulphate after the first (complex) reaction with permanganate and then completing the action with more permanganate, allowing, of course, for the permanganate value of the ferrous salt added. By these methods arsenic trioxide may be used for the standardisation of permanganate solutions, and arsenites may be used in the estimation of " available oxygen " in peroxides.

American Strategic Minerals

IN accordance with the Strategic Materials Act, which authorised the United States Bureau of Mines to appraise ore deposits containing metals that have been designated as strategic, the Bureau now has engineering parties in the field investigating the possibilities of eight mineralised areas. The deposits under investigation include antimony, chrome, manganese, tin and tungsten. When President Roosevelt, commenting on possible foreign war demands, recently called upon owners of commercial stocks of strategic minerals to refrain from selling them to foreign buyers because of their vital necessity to this nation and because of the restricted supply available here, these minerals were among those he named. According to the Bureau of Mines, since 1918 the strategic minerals situation of the United States has been improved in some respects but has become worse in others. The nation is now better off in regard to nitrates, potash, platinum, molybdenum, vanadium, pyrite and antimony than it was at that time, but the rapid increase in the use of alloys has made it more dependent than ever on foreign sources of manganese, chromium and nickel. The shortage in those materials was further aggravated by the depletion of the very limited high-grade reserves of manganese and chrome ores during the last war, and, in the case of nickel, by the transfer of refining operations from the United States to Canada. Since 1923, American manufacturers have obtained much of their ore for aluminium from South American bauxite deposits, and are still dependent entirely on overseas supplies of tin. While the prospects for disclosing large deposits of deficient strategic minerals of commercial grade are admittedly not bright, it is felt that relatively small deposits of commercial grade may be accompanied by " halos " of lower grade material containing sufficient quantities of needed metal that could be extracted if the demand for minerals becomes great. Eight projects in the West and South-West United States are therefore being explored with this emergency in mind, though the deposits of the metals involved are apparently for the most part either of low grade, of small quantity, or of scattered occurrence.

Ores in Indo-China

THE French authorities are closely investigating the possibility of establishing a metallurgical industry at Tonkin in French Indo-China where deposits of iron ore and anthracite of high quality have been discovered. As a first step, 1,000 tons of the iron ore and 3,000 tons of the anthracite have been shipped to France where they will be processed in the blast furnaces of the Pyrénées-Orientales. Large bauxite deposits containing some 45 to 50 per cent. alumina have been located near Lang-Song in French Indo-China. They may find application in the manufacture of *ciment fondu* in the event of their being found unsuitable for aluminium production.

THE MANUFACTURE OF ABRASIVES*

Important Advances and Future Trends

SILICON carbide and fused crystalline alumina are the companion foundations of the present day abrasive industry. Both are high temperature products of the electric furnace and both are creations of the electrochemist. From prehistoric time man has used natural abrasives such as sandstone to fashion his implements of war and peace.

Like many other products of chemical research, abrasives do not reach the average man directly in the sense that he does not eat them nor wear them nor frequently handle them, but they none the less touch his life intimately at many points. Perhaps the most profound effect comes from the fact that they are a key product in what we call mass production. Our present standards of living have been brought about largely through things made available by mass production.

The modern grinding wheel is largely the creation of the chemist. It is composed of hard, sharp abrasive grains and bond to hold them together. The strength and cutting properties of the articles made of these abrasives can be modified by varying the type and the amount of bond, the porosity and the size and kind of grit used. Bonds in established commercial use belong to five general types—vitrified (porcelain and glass), silicate (silicate of soda), resinoid (synthetic resin), rubber and shellac.

Plastics have now found their place in abrasive industry in meeting the demand for a grinding wheel revolving at a speed greatly in excess of the normal speed of 6,000 s.f.p.m. In many grinding operations efficiency and the amount of material removed increase rapidly with the higher speeds, and synthetic resins, preferably of the phenolic type, are now widely used as a binder in manufacturing the abrasive grains into wheels and other forms. Resinoid wheels are widely used for snagging steel castings, grinding billets and rolls and for cut-off wheels, which are very thin wheels used in the manner of rotary saws.

In snagging wheels the peripheral speed reaches 9,500 s.f.p.m. while cut-off wheels are operated at 16,000 s.f.p.m.

Cellulose is a raw material of vast industrial importance. In the form of pulp, it is a source of newsprint and other papers, and more recently of Cellophane, lacquer and rayon. The advances in the art of paper making have been largely chemical. For many years mechanical wood pulp has been produced by grinding logs with natural sandstone. In recent years the manufactured abrasive stone has been perfected and has now very widely replaced the natural stones. Their use has resulted in increased production and better pulp.

Segmental Wheels

These stones of manufactured abrasives are made by assembling around a steel centre segments composed of silicon carbide or aluminium oxide abrasive grains and a ceramic binder. These segmental wheels are now produced in sizes up to 72 in. in diameter and 54 in. wide, which is the largest grinding unit known to-day. So we have on one end of the abrasive scale a tiny dental point less than $\frac{1}{8}$ in. diameter and weighing 1/100 grams for grinding teeth, and at the other end the massive pulp stone weighing over three tons, or sufficient to make a quarter of a billion of the dental wheels.

The abrasive engineer is presented by modern industry with an ever changing problem of adapting his products to new materials or of accomplishing new objectives. Prof. C. C. Furnas, of Yale, has recently stated that the number of metal alloys in present commercial use is roughly equal to the number of stars visible to the naked eye. Each of these metals presents its peculiar problems to the abrasive maker and user. When, for example, chemistry gave to the world a super-steel product known as stainless steel, the difficult job of polishing large sheets of this material was turned over to the abrasive manufacturers, and most successfully solved.

The experience of the abrasive maker in the uniform distribution of granular particles in firmly bonded articles, together with certain outstanding chemical and electrical properties of his inherent materials has led him into a number of important allied lines which can be classed with abrasives even though abrasion is not involved. For instance, in recent years abrasives are making a unique contribution in combating disease and safeguarding public health, which have always been a major activity of the chemist. This is in the field of purification of public water supply and in the rapidly growing art of scientific treatment and disposal of sewage.

Uses of Silicon Carbide

In fractionating columns of chemical plants crude silicon carbide in lumps $\frac{1}{2}$ in. to 2 in. in diameter is finding new uses as a packing material. It operates at high efficiency, particularly in that it seems to increase the sharpness of the separation of the products being treated, and its complete inertness towards chemical liquids and vapours makes it valuable where corrosive substances are being handled. Several theories have been advanced to account for its efficiency, the most generally accepted being that it is due to the porosity of the product and to the innumerable sharp points and edges of the silicon carbide which act as condensation points.

In the chemical industry there is also a demand for catalyst carriers consisting of ceramic-bonded fused alumina grains, such as aggregates ranging in size from $\frac{1}{8}$ in. to $\frac{1}{2}$ in. The catalyst carrier aggregate is packed in towers, and the gas which is to be subjected to reaction is passed through the towers under pressure.

Silicon carbide is widely used in lightning arresters on electrical transmission and distribution lines for the protection of high voltage circuits. In one form the resistor consists of a column of granular silicon carbide in a chamber of insulating material. In another form it comprises a column of flat discs made of silicon carbide grains bonded by a ceramic binder. Silicon carbide possesses a peculiar electrical property which makes it valuable for lightning arrester work, namely, that as the voltage across it is increased, its resistance rapidly drops. Very few materials possess this valuable property.

In another type of silicon carbide resistors, current is passed continuously to heat the resistor to incandescence. Such heating elements are produced in a wide range of sizes extending from room heaters up to units liberating forty or fifty kilowatts each. These resistors have raised the temperature limit in commercial electric furnaces for large scale operation some 300° to 400° C. past the "Nichrome" range and have proved very useful in giving clean heat at these higher temperatures under controlled atmospheric conditions in both the metallurgical and ceramic industries. One of their incidental merits is that they can be secured for operation at standard voltages so that the furnace owner does not have to buy an expensive special transformer for his job.

It is of interest to note that hard materials widely used for abrasives find extensive use also because of their refractory properties. Both silicon carbide and aluminium oxide are very refractory and retain their strength and rigidity at very high temperature, and it may be assumed that the interatomic forces which are responsible for the extreme hardness of the

* Extracts from an article by Dr. Frank J. Tone in *Chemical Industries*, August, 1939: XLV, 2.

material require thermal energy of high intensity to break them down so the crystal no longer retains its rigidity but becomes liquid. The melting point, or the freezing point, of a pure crystal phase may be regarded as the temperature below which the crystal forces become sufficiently strong to overcome the random movement of the atoms or molecules within the liquid. If these crystal forces are very strong, it naturally follows that even at very high temperatures they can overcome the random movement which takes place within the liquid.

New Casting Technique

Until recently the extremely refractory particles of silicon carbide, fused alumina and the like were always bonded with other more fusible material such as clay when made into refractory shapes. Within the past few years, however, the technique of casting molten oxides such as alumina has been perfected so that the refractoriness of the crystalline material can now be fully utilised. As originally produced, such castings were very susceptible to heat shock and hence the widest use of these refractories has thus far been in the glass industry where the evenly sustained high temperatures have obviated any trouble from this factor. Additional research has in considerable measure now overcome this defect so that it is believed that steady extension of the use of this type of refractory in other fields may be expected.

It was found that the admixture of small amounts of various ingredients had a marked effect upon resistance to heat shock as well as the chemical properties of the material and a considerable number of superior modified refractories of this type are now available. They vary in chemical character from the relatively acid mullite type through the more neutral alumina group (modified with chromite in some instances) to highly basic materials. Due partly to the solidity of the castings which offer a minimum surface to attack, and partly to the qualities of the refractory materials themselves, many of the cast products have unusual chemical stability and are capable of resisting for prolonged periods the corrosive action of iron slags and even of molten caustic itself. Among the most interesting of these cast products is perhaps beta alumina, of which the density and thermal conductivity are both materially lower than those of the alpha form and which has shown outstanding resistance to fused fluoride glasses. Another useful material is boro-alumina ($3Al_2O_3.B_2O_3$). This new crystalline substance has high refractoriness, high electrical resistivity and a coefficient of expansion low enough to indicate it as an excellent ingredient for spark-plug bodies and the like.

A word should be said as to future trends in the abrasive field. The two standard abrasives, silicon carbide and crystalline aluminium oxide, are of sufficient hardness to grind almost every material commonly used in the arts, and as they are comparatively cheap and efficient there seems to be little likelihood of their being replaced by harder materials except for special applications. However, in certain lines of grinding there is a definite need and a definite quest for harder abrasive substances. There is a far wider gap in the hardness scale between silicon carbide and the diamond than is commonly realised and an abrasive which would be cheaper than the diamond and which approached it in hardness would be welcomed. Boron carbide is the only product yet developed as a commercial abrasive which has a hardness between silicon carbide and the diamond. There is little question but that this material as developed by Ridgway is the hardest synthetic material yet produced in quantities. It is used to some extent as an abrasive, especially in lapping operations, but its most important uses are in the fields where wear-resisting properties rather than cutting ability are required, paricularly as sandblast nozzles and dies.

Research in the Carbides

In the quest for harder materials, some noteworthy research has already been carried out in dissolving various other carbides in fused boron carbide. When various carbides are fused with boron carbide and cooled they are crystallised from the boron carbide which acts as a solvent. The carbides of tungsten, tantalum, vanadium, zirconium and the like, dissolve readily in boron carbide and crystallise from the melt as separate crystals. In fusing silicon carbide in boron carbide, it is found that approximately 35 per cent. of silicon carbide can be added to boron carbide without destroying the continuity of the matrix.

Cast Iron in the Ladle

Agents for Modifying its Properties

THE technique of treating cast iron in the ladle, or in the case of furnaces other than the cupola, in the furnace just prior to pouring, can be of great use to foundries. Mr. A. J. Nicol Smith, in a paper published in the *Bulletin of the British Cast Iron Research Association*, reviews the methods now available. The control of chilling properties, he remarks, is one of the most important elements in foundry-work. It may be viewed from two angles: the control of chill to a standard limit for a given purpose; and the control of chill to different degrees for different purposes. The first-mentioned object has been attained for many years, particularly in the manufacture of chilled rolls, by the addition to the ladle of a quantity of molten iron of softer composition than the bulk of the metal so as to reduce the chill to a known extent. Conversely, the chill may be increased by adding a quantity of separately melted harder iron. Of recent years the ladle addition of alloys has become more widely practised and chill properties are controlled to a standard by means of suitable additions. The control of chill, not to one standard, but to different degrees for different purposes, is not so widely practised, but is nevertheless a useful foundry method. By such means it is possible to adapt a standard cupola iron to a variety of uses.

The agents which can be used to increase chill are harder iron, ferro-chromium, ferro-manganese and steel scrap. The addition of a known quantity of low silicon iron separately melted in, for example, a crucible furnace, constitutes a good and reliable method of increasing chill without diminution of metal temperature, though the method needs some control to assure that the crucible metal is ready at the right time. The addition of ferro-chromium is often used for increasing chill and ferro-manganese has a similar but less drastic action. Chill is reduced by the addition of the alloys nickel and copper, also by the addition of silicon, usually as ferro-silicon and by inoculants such as calcium silicide or silicon metal. Ferro-silicon and the other inoculants when added just before pouring have the property of producing a graphitising effect which is greater in proportion than the alteration in composition would lead one to expect. These substances also give some degree of control of the graphite structure and size and thus influence the strength of the resulting iron. Their main use is, in fact, for this purpose, but the reduction of chill which they render is of great importance and use in the foundry. Under the heading of processes designed to afford control of the graphite size and distribution, one of the most important items is the process, patented by the Association, by which the graphite is reduced to the very fine supercooled type by treating the melt with carbon dioxide in the presence of titanium, which may either be added to the melt or may be present in the pig iron. This treatment is being applied to cupola-melted irons and can give important advantages in strength and in soundness and

freedom from porosity. It is being experimented with and used commercially.

Methods of improving the strength properties of cast iron by ladle additions usually concentrate on the addition of alloys although the processes designed to effect graphite control also give improvements in strength properties. The alloys or special elements commonly added to cast iron are nickel, copper, chromium and molybdenum. Of these, nickel and copper are graphitising agents, while the other two give an increase in chill. It is therefore often convenient to add two alloys in such proportions that the chill properties of the iron are undisturbed. For this purpose it may be taken that nickel and copper are equal in graphitising value and that each will balance the chill due to an equal quantity of molybdenum or to one-third of the quantity of chromium. The quantity of alloy which can be added to the cupola spout or to the ladle is limited, owing to the cooling effect on the metal, but this restriction applies chiefly to the cupola and less in cases where the addition may be made in the furnace. It is possible to preheat the alloys or even to melt them in a separate furnace, with or without a small quantity of pig iron, in order to minimise this trouble. The hotter the metal melted the greater the quantity of alloy that can be dissolved without lowering the temperature below the permissible limit and, of course, the low limit of temperature is decided by the castings to be poured. Alloys in small quantities have little influence on the fluidity of the metal apart from their effect on its temperature. The influence of alloy additions, in small quantities such as can be added in the ladle, is in general to increase the hardness, to improve the strength and wearing qualities and in a small degree to promote improved corrosion and heat-resisting properties. The technique of making alloy additions balanced with respect to chilling effect is of great use in foundry work in enabling odd quantities of stronger or harder iron to be made from a standard mixture without the trouble of resorting to special cupola charges with all their attendant difficulties of separation.

Methods of Alloy Addition

Of the general methods of adding alloys to the ladle the most common is to shake the alloy in a finely divided form into the stream of metal as it issues from the cupola spout. The addition should commence when the bottom of the ladle is well covered and be complete by the time that half of the metal is tapped. The rest of the metal falling into the ladle then gives a stirring action. Should any of the powder cake and float on the ladle surface, it should be pushed well under the metal or under the descending stream from the spout. It is difficult to better the method of shaking the powder into the stream by hand, especially if this be done from a shaped scoop. Nickel and copper can both be obtained in small particles of light weight and thin section or may be added as lumps to the ladle before tapping the metal. Another method of adding lump alloys to cast iron which has been practised with ferro-silicon and with copper, and would doubtless be effective with nickel, is to place the alloys in a perforated receptacle so arranged that the cupola stream runs into it and out through the hole or holes dissolving the alloys as it goes. The receptacle may be made much on the lines of a small ladle, from sheet steel lined with refractory material or can be improvised by drilling holes in a crucible. It should be remembered that, with the possible exception of copper, alloys dissolve in cast iron rather than melt and that oxidation losses of the alloys occur most readily when the alloy tends to float on the surface. The addition of finely divided alloys to hot metal is the best preventive of oxidation. Copper additions can show a tendency to melt and form a separate liquid layer below the iron, and stirring should therefore be carried out carefully.

Properties of Suspension Media

Float-and-Sink Concentration*

METALLURGISTS and coal-washing engineers have used heavy liquids for years in studying the characteristics of ores and coal. By such means true separations can be made between the various specific-gravity increments in the materials examined. The use of heavy liquids has permitted determination of the possible grades of tailings and concentrates by specific gravity methods on any particular size and therefore the size to which an ore must be crushed so as to free the valuable material from the gangue.

The simplicity of float-and-sink separation and the high degree of efficiency attained in the laboratory are factors that commend the method for commercial concentrations. It has been known for many years that if solid particles are freely suspended or maintained in suspension by agitation in water, the pulp or suspension possesses many properties of a liquid, particularly with respect to the ability to float particles of lower specific gravity and to allow denser particles to sink.

Media for Suspensions

Liquid suspensions heavier than water can be made by agitating solid particles having a specific gravity greater than 1.0 in water. The specific gravity of the suspended material determines to a large degree the specific gravity of the suspension. If a suspension heavy enough to float coal is desired, a liquid having a gravity high enough (1.35 to 1.55) can be made by suspending such a mineral as quartz sand (sp. gr. 2.65) in water. If, however, a suspension heavy enough to float quartz or calcite is needed, a heavier mineral must be used. Other factors than specific gravity that affect the choice of the medium are cost, shape of particle, resistance to abrasion, resistance to corrosion, chemical inertness, and ready recoverability from waste.

Ferrosilicons

Of the various ferrous alloys, ferrosilicons have attracted most attention because they can be ground easily, they resist oxidation and corrosion in air and water, have suitable specific gravity and desirable magnetic properties, and are cheap. The term "ferrosilicon" is applied to an entire series of alloys of iron and silicon containing up to 90 per cent. silicon. However, from the standpoint of physical properties, the alloys containing 10 to 20 per cent. probably are superior to the others. Alloys containing less than 8 or 9 per cent. silicon oxidise fairly readily. The magnetic susceptibility drops rather rapidly in alloys containing more than 15 or 20 per cent. silicon, and as a high magnetic susceptibility is desirable for purification, alloys containing more than this percentage of silicon are not desirable. The specific gravities of the alloys containing 10, 15, and 25 per cent. silicon are, respectively, 7.0, 6.8, and 6.3. Ferrosilicons within the range of 10 to 25 per cent. silicon can be crushed to a powder by rolls, rod, or ball mills. Alloys containing less than 5 per cent. silicon are ductile and malleable and cannot be crushed easily. According to Corson, the Rockwell "C" hardness of the ferrosilicons increases from 24 (248 Brinell) for a 4 per cent. silicon to 59 (495 Brinell) for a 14 per cent. alloy. The hardness in the range of alloys from 14 to 24 per cent. silicon remains constant at this figure. From a consideration of the above properties, it seems evident that a ferrosilicon of approximately 15 per cent. silicon content has the best general properties of all the alloys in the series. Present cost of the

* This report by F. D. DeVaney and S. M. Shelton represents the results of co-operative work between the Bureau of Mines, United States Department of the Interior, and the Missouri School of Mines and Metallurgy, Rolla, Mo.

15 per cent. alloy crushed to 100 mesh is believed to be approximately £60 per ton in large lots.

The specific gravity of 15 per cent. ferrosilicon (6.8) is somewhat less than that of galena (7.5), and suspensions having a maximum gravity of about 3.5 can be made of it. In plant operations allowing for some contamination, probably the upper working limit is about 3.2. Ferrosilicon is hard and does not abrade to any degree. There is a slight tendency for the 15 per cent. variety to oxidise, but the operators of the Patrick unit claim that this can virtually be eliminated by adding a small amount of lime to the circuit. The high magnetic susceptibility is definitely in its favour as it permits the diluted medium from the washing screens to be magnetised to facilitate settling. Any non-magnetic material that has contaminated the medium can be rejected by passage through a magnetic concentrator.

Lead is the only non-ferrous metal that has been examined It is one of the cheapest of the non-ferrous metals and has a very high specific gravity (11.3). It is available commercially as a fine metallic powder consisting of globular particles known as atomised lead. Suspensions with a density of 6.2 can be made from it, and at 5.0 it is quite fluid. These high-specific-gravity pulps may prove to have definite value for special separations. Lead is soft, but as it is also malleable it is difficult to say how badly it would abrade. The chief drawback to its use as a suspension medium is that the fine sizes oxidise rapidly in water and in air. A suspension of minus-200-mesh atomised lead in water if left to dry will set like concrete and will not redisperse when additional water is added. In all probability a basic lead carbonate is formed, although if sulphates are present, probably lead sulphates also are formed. The use of inhibiting agents such as sulphides to retard oxidation shows promise but has been only partly investigated.

Some Recent Metallurgical Patents

Alloys

Alloys, particularly for resistance wire for electric heaters and the like, of the type comprising nickel and chromium or nickel, chromium, and iron, with or without tungsten, molybdenum, cobalt, manganese, aluminium, or uranium, contain also 0.01-2 per cent. of thorium and 0.25-3 per cent. of silicon, with or without any of the following: 0.01-2 per cent. of rare earth metal such as cerium, 0.01-0.5 per cent. of alkaline earth metal such as calcium, and 0.01-1 per cent. of zirconium. 0.01-0.5 per cent. of magnesium may be added for deoxidising purposes. (See Specification 507,167 to British Driver-Harris Co., Ltd., and W. M. Kay.)

Reducing Size of Metals

A supply conductor sealed within a high pressure metal-vapour electric discharge tube of quartz or highly refractory glass, consists of a continuous one-piece member having, over part of its length within the seal, a smaller section than the cross-section over another part of its length which is also within the seal and extends outwardly or inwardly of the discharge tube, the transition from the large to the small section part of the sealed-in conductor being effected gradually without sudden variation of section. Both ends of the thin part of the conductor within the seal merge gradually into thicker parts, the inside portion constituting an electrode provided with an electron-emitting coating. An auxiliary electrode is constituted by a tungsten wire which has a thick portion extending from within the seal to the exterior of the tube, and a thinner portion at the other extremity within the tube, there being a gradual transition region between the thinner and thicker parts. The section of the supply conductor may be reduced by burning in an oxygenous medium preferably by means of a blow-pipe flame or by etching, electrolysis or grinding. A suitable etching medium for use with tungsten or molybdenum wire consists of 300 gms. of potassium ferri-cyanide, 45 gms. of caustic soda-lye, and 1,000 gms. of water. Alternatively a mixture of equal parts of concentrated nitric acid and hydrofluoric acid (60 per cent.) may be used. For the electrolytic method the electrolyte may consist of caustic soda-lye with the tungsten or molybdenum conductor connected as anode. (See Specification 506,469 to N. V. Philips' Gloeilampen-Fabrieken.)

Extracting Alkali Metals

Mercury is removed from mixtures of mercury and alkali-metals, *e.g.*, sodium with or without potassium, by treatment above the melting point of the mixture with an alkaline-earth metal (including magnesium). The mixture is allowed to settle and the solid mercury-containing material is removed, *e.g.*, by filtration or centrifuging, and is heated in a retort to drive off mercury, the residue, which contains calcium and a little mercury and alkali metal, being used for the treatment of a fresh batch of amalgam. In order to keep the mixture undergoing treatment liquid at a convenient temperature, *e.g.*, 200° to 300° C., or 600° to 800° C., alkali-metal may be added. Conveniently, the alkali-metal present should amount to 75 per cent. by weight of the mixture present and in any case may exceed the weight of mercury present, being, for example, 3 to 5 or 10 to 15 times as much. The operation may be carried out under an inert gas and glass wool may be used as the filtering-medium. The alkaline-earth metal, *e.g.*, calcium, should be used in subdivided form produced by cutting, abrading or by precipitation from a solution in alkali-metal carried out, *e.g.*, by cooling to about 200° C. a solution prepared under an inert gas at 500° to 800° C., or derived from the electrolysis of fused sodium and calcium salts, and filtering through steel wire cloth. (See Specification 505,097 to Du Pont De Nemours and Co., E.I.)

Alloys : Heat Treatment

A light alloy with high elastic limit, strength, and freedom from intercrystalline corrosion comprises 5 to 6.5 per cent. of zinc, 2 to 3.5 per cent. of magnesium, 0.15 to 0.5 per cent. of silicon, 0.2 to 0.6 per cent. of each of molybdenum and cobalt, 0 to 0.12 per cent. of potassium, 0 to 0.25 per cent. of barium, 0 to 0.1 per cent. of antimony, 0 to 0.5 per cent. of tungsten, 0 to 1 per cent. of nickel, 0 to 0.4 per cent. of titanium, the remainder being aluminium. The alloys may be tempered at 450° to 550° C. or double tempered at 530° to 550° C. or may be tempered to at least 480° C., aged for 8 days at the surrounding temperature, and then tempered at 80° to 160° C. for 3 to 17 hours. Moreover they may be rendered easy for wire-drawing or stretching by immersion for 24 to 48 hours in a mixture of nitrates of sodium and potassium at 420° C. prior to thermal treatment whereby metals such as magnesium are removed from the surface. Specific alloys may be (*a*) heated to 450° to 550° C. cooled in air, water or other liquid, aged, for instance by being held at 48 hours at the surrounding temperature, and tempered at 80° to 160° C. for 3 to 17 hours, and (*b*) double tempered at 530° C., aged at the surrounding temperature for 48 hours, and tempered. In making the alloys, silicon, manganese, and magnesium serve as deoxidisers, 95 per cent. of these metals so employed remaining as constituents of the alloy. Potassium and barium are added as the respective chlorides in amount equal to 0.25 per cent. and 0.5 per cent. of the alloy respectively, whereby oxides are reduced and gases eliminated, and the metals in question added to the alloy. (See Specification 505,728 to Electrique Association Cooperative d'Ouvriers en Materiel Electrique and I. Hanco.)

Metallurgical Section

December 2, 1939

MANGANESE ORE IN WARTIME

Problems of the Supply from the U.S.S.R.

By

D. D. HOWAT, B.Sc., A.Inst.M.M., A.I.C., Ph.D.

A SIGNIFICANT little paragraph appeared in the Press a few weeks ago. It was headed "Washington" and merely stated that Soviet Russia has offered to sell to the United States of America about five million dollars' worth of manganese ore. This manganese ore, it continues, is a vital military necessity which Russia has been expecting to supply in considerable quantities to Germany. A message from the official German News Agency, while admitting that Russia is supplying manganese ore to the United States, makes light of the fact, maintaining that Russia is first supplying Germany and then releasing her surplus ore to other countries.

It is an admitted fact that manganese ore is a vital military necessity, because it is an essential of almost all steel-making processes. With the possible exception of the crucible process of steel-making, manganese is required for all steels made by the open-hearth and Bessemer processes. If supplies of manganese are not available the entire basis of modern production would require to be modified and a great deal of existent plant would become obsolete. At that stage in the manufacture, when the refining of the steel has been completed, the molten bath of steel contains appreciable quantities of oxygen, which were essential for the removal of the impurities present, but whose presence is no longer required, and if these were allowed to remain would result in the production of a steel that would be exceedingly brittle and unable to be rolled or forged, and would be completely useless from an engineering point of view. So, just before the liquid steel is poured from the ladle into ingot moulds, quantities of manganese are added. This reacts with the oxygen in the liquid steel which is present as iron oxide, forming the insoluble manganese oxide which passes into the slag and so prevents the steel from becoming "cold short." Manganese is used for two other purposes also, first for the removal of excess sulphur, and then for adding the necessary amount of carbon to the liquid steel. A small quantity of manganese (about 0.5—0.7 per cent.) remains in the finished steel, and the presence of this residue has very beneficial effects on the mechanical properties of the steel.

Manganese is added also in much larger quantities to produce special types of alloy steels, particularly those used to resist abrasion and wear. The cross-over points of railway tracks and curved rails with sharp radii are made of steels containing up to 12 per cent. manganese.

The Chief Alloys

For use in steel manufacture manganese is employed in the form of iron-manganese alloys. There are two main types of these alloys: spiegeleisen, containing 15—25 per cent. manganese, and ferromanganese, containing 78—82 per cent. of the metal. Both these alloys are made by treating manganese ores in blast furnaces or electric furnaces. Spiegeleisen can be made from low-grade ores containing less than 30 per cent. manganese. These ores are relatively plentiful, but the alloy is not so suitable for steel manufacture as the higher alloy ferromanganese. The latter is produced in the same way as spiegeleisen, but can be made only from high-grade ores containing over 45 per cent. manganese.

It is the supply of these high-grade ores which constitutes one important problem for the large steel-producing countries of the world. It is rather anomalous that with the exception of Russia none of these countries—the U.S.A., Germany, Britain and France—can supply even a minute fraction of the necessary manganese from internal sources. A reasonable figure for the amount of manganese required will be about 0.6 tons of the metal for each 100 tons of steel produced. Thus the U.S.A., with its annual production of about 50 million tons, will need about 300,000 tons of the metal, Germany about 120,000 tons, Britain 85,000 and France 60,000 tons.

Manganese Production Figures

Until a few years ago the main sources of manganese ores were Russia, India and Brazil, but recently the Gold Coast Colony, the Union of South Africa, Cuba and Egypt have come to occupy very important places as sources of manganese ores. The production of manganese ore from these countries during 1935, 1936 and 1937 is given below.

Country.	Manganese Ore. 1935.	1936.	1937.	Manganese Content. 1935.	1936.	1937.
U.S.S.R. ..	2,346,900	2,955,000	2,750,000	—	—	—
India ..	641,483	813,442	1,051,594	321,000	407,000	526,000
Brazil ..	59,711	163,842	256,054	28,100	77,000	120,000
Gold Coast ..	430,659	411,024	527,036	224,000	214,000	274,000
South Africa	93,943	254,167	621,229	47,253	119,214	264,581
Cuba	90,650	151,981	130,000	17,223	30,000	60,000
Egypt ..	85,924	132,840	183,377	25,087	38,524	53,179
World Total	4,100,000	5,300,000	5,780,000			
British Empire production	1,700,000	1,520,000	2,240,000			

Two rather important facts were pointed out in a recent edition of *Mineral Industry*. First, that the estimated world production of ore in 1937 was nearly 6,000,000 tons, while that required to meet the steel production was only about 3,400,000 tons, the deduction being that quite large quantities of this ore must have been stored against future emergencies. The second is that, since 1934, in Russia there has been an excess of ore production over consumption and export that amounted in 1937 to over 5,000,000 tons.

Deposits of manganese ores are composed of the various oxides of the metal that have been deposited in sedimentary beds or have been concentrated by the action of surface waters on weathered manganiferous rocks from which the impurities have been dissolved and carried away. The ore-bodies are usually within 160 feet of the surface and are contained within light friable rocks, e.g., laterites in the Gold Coast, so that mining is very simple and no extensive deep drilling and blasting are necessary. Open-cut operations are generally all that is required.

The Russian deposits are in the Transcaucasian district; there are two large mines, the first at Tchiaturi and the second at Nikopol. Tchiaturi is about 126 miles from the port of shipment on the Black Sea, and so, during the war

of 1914—1918, the closing of the Dardanelles was a severe blow to this trade. The Tchiaturi deposit may be classed as the largest single deposit now known. It covers some 22 square miles.

The announcement quoted earlier regarding the sale of Russian manganese ore to the U.S.A is probably nothing more than an ordinary commercial transaction, as Russia is the largest supplier of these ores to the States, which in 1937 absorbed 383,951 tons out of the total exports of about 1,000,0000 tons. The next largest supplier of manganese ore to America is the Gold Coast Colony. From the deposits at Insuta, about 40 miles from the port of Takoradi, about 250,000 tons of ore containing 52 per cent. manganese have been consigned annually since 1936. Britain's needs are supplied almost entirely from India. The amounts of manganese ore imported during the last three years have varied from 200,000 to 280,000 tons and 80-85 per cent. of this total is imported from India.

The tonnage and sources of imports of manganese ore to Germany during the years 1935, 1936 and 1937 are given.

Imports of Manganese Ore to Germany.

	1935	1936	1937
U.S.S.R.	61,835	32,082	61,336
India	73,354	51,118	121,318
Egypt	708	7,796	98
Dutch East Indies ...	6,054	5,571	5,652
Union of South Africa ...	31,015	108,602	290,680
Gold Coast Colony ...	35,679	—	—
Others	19,097	24,264	75,085
Total	227,742	229,633	554,169

Effect of Barter Agreements

Three factors in this summary are worth noting. First, the enormous increase in the tonnage of ore imported from the Union of South Africa. The amount imported from this source alone was greater in 1937 than the total imports from all sources in the two previous years, while in 1934 the amount imported was only 19,232 tons. This trade must have been a very important part of the "Barter Agreement" which was in force between Germany and the Union until September 5, 1939. Second, the increase in the imports from India, which in 1937 were 2½ times the amount the previous year. Third, that the imports of ore in 1937 were almost double the average tonnage for a number of years previously.

When the effects of the blockade on Germany's imports of this ore are considered the position is obviously serious. India and the Union of South Africa have automatically ceased supplying, and in 1937 these supplies comprised 74 per cent. of the total imports. It is this which probably accounts for the fact that twice the amount of ore was imported into Germany in 1937 as compared with the previous average. It is equally probable that almost the same surplus was accumulated during last year. It is a fair assumption that Germany is in possession of a stock of manganese ore sufficient to meet normal requirements for a period of one and a half to two years. How long this stock will last under the conditions of accelerated demand in war is a different matter.

The problem of further supplies is one to which no solution can be found. Even supplies of ore from Soviet Russia are very problematical, for the simple reason that the only practical way out is through the Black Sea and it is highly unlikely that ships carrying such cargoes would reach Germany under the blockade conditions. The transport of large supplies of ore by railway over the colossal distances between the Caucasus and Germany would be exceedingly difficult if not impossible. The only possible source of supply in Europe is Czechoslovakia, from which over 100,000 tons were produced in 1937, but these are only low-grade ores with 15—17 per cent. manganese. If the present struggle continues for long, the replenishment of the stock of manganese ore will not be the least of the many problems confronting Nazi Germany.

New Control Orders

Iron and Steel Products and Scrap

THE Control of Iron and Steel (No. 4) Order, 1939, dated October 31, which was brought into operation as from November 1, fixes new prices for iron and steel products. The prices in operation prior to the outbreak of war for the main range of products had been fixed by the British Iron and Steel Federation with the approval of the Import Duties Advisory Committee until October 31, and they were continued at their pre-war level by the original Order made by the Minister of Supply and dated September 1, 1939, and the Control of Iron and Steel (No. 2) Order, dated September 22.

The new prices take account of the increased costs of the principal imported raw materials including the higher freight charges now in operation. The effect of the Order is to increase the prices of billets and heavy steel by £1 per ton with corresponding adjustments in the prices of finished products. The Order also brings within the schedule of maximum prices home iron ore and a number of iron and steel products not hitherto covered by the statutory control. In the case of home iron ore the maximum prices fixed are based on those at present in operation. The prices of those iron and steel products not hitherto included are generally on the same basis as those of the main range of products.

Under the direction attached to the new Order pig iron as well as high-speed steel has been excepted from the various exemptions from licences.

New prices for iron and steel scrap are fixed by the Iron and Steel (No. 5) (Scrap) Order, 1939, made by the Minister of Supply, which came into force on November 17. This Order replaces the Control of Iron and Steel (No. 3) (Scrap) Order, 1939.

The general level of prices under the Order remains unchanged, but adjustments have been made in a number of cases where the prices originally fixed were found to create anomalies or to work inequitably. Provision is made in the Order for fixing maximum prices for any type of iron or steel scrap not covered by the Order, and also for fixing a special maximum price in cases where, by reason of transport or other difficulties, a consumer is not able to obtain adequate supplies within his usual area of supply at the controlled price. The main purpose of this last provision is to enable the consumer, when a shortage of scrap exists in his normal area of supply, to pay, in approved cases, the extra cost of transport of scrap from another area. Maximum prices have now been fixed for scrap iron and steel used in the manufacture of refined pig iron.

The Direction (No. 1) under the Order issued therewith repeats the provisions of the similar Direction under the previous Order, exempting the sale and purchase of scrap from the requirement of licence, except for certain special types.

Aluminium Control

The Control of Aluminium (No. 4) Order, 1939, dated November 21, 1939, was brought into operation as from November 24. The order provides that no person shall acquire or dispose of any virgin aluminium situate in the United Kingdom except from or to the Minister of Supply, nor dispose of any virgin aluminium alloy unless the aluminium content thereof has been acquired from the Minister of Supply. Also any person acquiring any of these materials shall comply with any conditions imposed.

Further provisions prohibit dealing, except under licence granted by the Minister of Supply, in secondary or re-melted aluminium, unwrought aluminium alloy, and aluminium scrap; and forbid buying or selling of these materials at a price exceeding any maximum price that may be fixed. The control of undertakings involving the treatment, storage and transport of aluminium and aluminium ores and products is likewise provided for. The Control of Aluminium (No. 3) Order, 1939, is revoked, except that any licence granted under that Order shall remain effective, unless in respect of virgin aluminium.

Current Topics

Magnesite as a War Material

THE use of magnesite in war time was one of the points dealt with by Mr. A. W. Comber in the 22nd Streatfield Memorial Lecture recently published by the Institute of Chemistry in pamphlet form. Under existing conditions of industrial production, the lecture points out, magnesite may be classed as an essential commodity for war time needs in two chief connections, as a refractory lining for furnaces for the manufacture of steel, both in the basic open-hearth process and in the blending of special alloy steels; and as a raw material for the extraction of metallic magnesium, in any of the processes now operating in this country. With especial reference to these two needs, it has recently been suggested that Britain, which has no native resources of magnesite, should become independent of imported supplies by substituting the use of dolomite, which occurs extensively in the Midlands and North Country. Calcined or "shrunk" dolomite has been used for many years as a basic refractory in the steel industry, but the only advantage it has in comparison with magnesite is its cheapness. The chief objection to it lies in the fact that, unlike magnesite, it is hygroscopic, but in practically every other respect also its inferiority is apparent. It is not suitable for making bricks unless these are protected against hydration by such devices as coating with tar and wrapping in paper, and its working life, even under the most favourable conditions, is much shorter than that of magnesite. If a furnace lined with dolomite has for any reason to stand idle for more than a few days, the material hydrates and deteriorates very quickly in the absence of heat, entailing replacement before again firing up. There have been many efforts to produce a dolomite brick which is non-hygroscopic after firing, but the results have not been successful enough to warrant general application.

Replacement by Dolomite

THE average British dolomite contains about 12 per cent., and a reasonably pure amorphous magnesite (supplies of which are obtainable from Empire sources) 28 per cent. of magnesium. Dolomite now has quite a minor importance in modern steelworks practice and any attempt to rely upon it solely, or even substantially, for replacement of magnesite as an emergency measure would, without doubt, have a very damaging effect on British steel production, especially in circumstances where continuous output at maximum rate is demanded. This consideration would be of the gravest importance in regard to the output of alloy steels, which are essential factors in the manufacture of war supplies. Experimental work has, however, been on hand for some time in connection with one important process in this country, and it is hoped that the substitution of magnesite by dolomite may eventually prove to be a practicable proposition. But in a general sense any enforced replacement of this nature, as a war-time expedient for British extraction plants, would inevitably cause serious dislocation of existing practice and a slowing down of the rate of production.

Columbium-Bearing Steels

A FORTUNATE correlation generally exists in the development of useful alloys and the ease with which they can be welded. In this respect metallurgical science has made further outstanding advances in the past year. Improved alloys—particularly the stabilised stainless steels, the columbium-bearing 4 to 6 per cent. chromium steels, the high-tensile structural steels, and the chromium-alloy grey cast irons—have gained wide acceptance in many fields of application. The satisfactory results obtained when these alloys are welded contribute to their popularity. Welded assemblies of columbium-bearing stainless steel are meeting the demand for industrial equipment giving excellent service when exposed to corrosive agents and high temperatures. Aircraft engine exhaust manifolds, oil-cracking stills, and chemical mixing vats are examples of the use of this modern alloy. Although stainless steel is used in increasing amounts by most of the major industries—petroleum, chemical, power, and the various branches of transport—the miscellaneous applications are said to account for more than one-third of all the stainless steel produced in the last year. This is very encouraging to operators of welding equipment, because the adaptability of welding makes the process especially suitable for fabricating a wide variety of unusual or irregular shapes. Stainless steel furniture, kitchen equipment, and architectural " hardware " are particularly promising fields for welded fabrication. Improvements in 4 to 6 per cent. chromium steel are obtained by the addition of columbium. Not only is greater oxidation resistance, toughness, and strength at high temperatures obtained but increased ductility in the weld zones makes the columbium-bearing steel desirable for oxy-acetylene welded installations. These improvements increase the serviceability of the steel in equipment and piping for high-temperature use in the petroleum, chemical and power industries.

Chromium-Alloy Cast Iron

CHROMIUM-bearing grey cast iron is becoming widely recognised for its soundness, good physical properties and heat-resistant characteristics. One type, which also contains copper, is used for cast iron pipe. Short lengths can readily be joined to form longer lengths by welding. Installations can likewise be made by this method. Progress has also been made in the gas cutting of alloy steels. The shape-cutting of low-alloy, high-tensile engineering steels is now being done in large scale production, and a new method has been worked out for flame-cutting stainless-clad steel. The principle of this new method depends on the fluxing action of the carbon steel layer.

GAS PRODUCERS ON VEHICLES

As announced in Parliament on November 8, a design of producer gas generating apparatus suitable for use with road transport vehicles has been developed, and will be made available to firms able and willing to undertake manufacture. All inquiries about this apparatus should be addressed in the first instance to the Director of Fuel Research, Fuel Research Station, River Way, Blackwall Lane, E. Greenwich, S.E.10. Firms interested in the possible manufacture of the producer should give some indication of the manufacturing facilities they have available and the type of work on which they have had previous experience. The design in question has been prepared for large scale production involving the use of steel pressings.

A cinnabar deposit—the exact extent of which has not yet been established—has been discovered at Dom Bosco in the Minas Geraes Province of Brazil, according to the Brazilian Federal Ministry of Agriculture.

Some Recent Metallurgical Patents

Coating with Metals

In coating tubes, sheets, and other iron articles by the lead-zinc process in which the objects are introduced into the lead and withdrawn through the layer of zinc floating on the lead, the objects are introduced into the lead bath immediatey after pretreatment with an aqueous solution of ammonium chloride and zinc chloride, the proportion of ammonium chloride to zinc chloride being preferably between 1 to 5 and 1 to 10. The container for the molten bath is preferably made of iron poor in carbon and the articles are introduced into the lead through a frame made of a material not attacked by lead or lead-zinc alloy. Specifications 281,357 and 287,210 [both in *Class* 82 (ii)], are referred to. (See Specification 508,117 to Armstrong J. J. V. (Mitterdeutsche Stahlwerke Akt.-Ges.)

Alloys

An alloy containing as main ingredients lead and copper and, if desired tin, is made by alloying with these metals an auxiliary alloy comprising copper, nickel, manganese, iron, phosphorus, aluminium, tin, and silver. In making the auxiliary alloy 72.085—59.574 parts of copper are melted together with 26-31.426 parts of nickel, to which are added 0.491-2 parts of manganese and 0.491 part of iron, then 0.442-5 parts of phosphorus, and 0.491-1 part of an aluminium alloy containing 88.23 per cent. of aluminium, 5.31 per cent. of copper, 2.65 per cent. of tin, 0.88 per cent. of nickel, 0.88 per cent. of magnesium, 1.66 per cent. of manganese, and 0.39 per cent. of silver. In making this aluminium alloy, the copper, manganese, and nickel are melted together and added to the aluminium which is molten, and the tin and magntsium are added to the resultant mass. The silver is then added. The auxiliary alloy is added in the proportion of 3-10 per cent. of the final alloy to copper and then 10-60 per cent. of lead are added and, if desired, tin. (See Specification 507,903 to Whitman, H. L.)

Alloy Steel : Heat Treatment

Welded constructional elements, for example for aircraft, having a minimum strength at the weld of 60 kilograms per square millimetre without brittleness, are made from an alloy steel capable of precipitation hardening and containing 0.05-0.25 per cent. of carbon, 0.3-0.8 per cent. of manganese, 0.1-0.5 per cent. of silicon, 0.2-2.0 per cent. of molybdenum, 0.1-1.0 per cent. of vanadium, and 0.25-3.0 per cent. of copper, but no titanium. The steel may be subjected to precipitation hardening by tempering between about 400 and 800° C., and preferably between about 450 and 700° C., with or without a previous normalising treatment, or it may be normalised only. Specification 445,842 is referred to. (See Specification 506,640 to Schoeller-Bleckmann Stahlwerke A.-G.)

The Institute of Metals

Officers for 1940

AT a formal general meeting of the Institute of Metals, held in London on November 16 in place of the cancelled September Glasgow meeting, the under-named nominations were made to fill vacancies occurring on the Council next year.

As President : Lieutenant-Colonel the Hon. R. M. Preston, D.S.O., Managing Director, Rio Tinto Co., Ltd. As Vice-Presidents : Dr. S. F. Dorey, Chief Engineer Surveyor, Lloyd's Register of Shipping; Engineer Vice-Admiral Sir George Preece, K.C.B., Engineer-in-Chief of the Fleet, Mr. A. J. G. Smout, Chairman of metal group companies of Imperial Chemical Industries, Ltd. As Hon. Treasurer : Lieutenant General Sir J. Ronald E. Charles, K.C.B., C.M.G., D.S.O., Director, British Aluminium Co., Ltd. As Members of Council : Dr. W. E. Alkins, Research Manager, Thomas Bolton and Sons, Ltd.; Mr. G. L. Bailey, M.Sc., Chief Officer, Development Department, British Non-Ferrous Metals Research Association; Mr. F. C. Braby, M.C., B.Sc., Director and London General Manager, Frederick Braby and Co., Ltd.; Colonel P. G. J. Gueterbock, D.S.O., M.C., T.D., M.A., Managing Director, Capper Pass and Son, Ltd.; Dr. D. Hanson, Professor of Metallurgy, The University of Birmingham.

CAST IRON RESEARCH

Although the plans for the Fourth Study Course in November were abandoned, the British Cast Iron Research Association will continue to perform the services for which it was formed and which members have now come to expect. This applies both to the headquarters and Scottish laboratories. The addresses and telephone numbers are unchanged. The Association is actively taking part in movements to ensure that the requirements of H.M. Government for cast irons may be met, and to ensure the widest possible use of cast iron in applications not previously considered. This will enable the industry to play its part in national defence and help to relieve the strain on existing productive resources of other metals, ferrous and non-ferrous. The *Bulletin* will, for the time being, revert to a quarterly publication.

Silica Basins and Crucibles

New Standard Specification

A new British Standard for Silica Basins, Crucibles and Capsules (B.S. No. 875-1939) has recently been published, and forms part of a series of British Standards for Scientific Glassware and Silica Ware. Parts 1 and 2 deal with Basins and Crucibles respectively and give the range of sizes, material from which they are to be made, and tables of dimensions. Part 3 is confined to Capsules with lid for combined moisture and ash determination and deals also with the material and dimensions. Copies of this new British Standard may be obtained from the British Standards Institution, 28 Victoria Street, London, S.W.1, price 2s. 2d. post free.

THE IRON AND STEEL INSTITUTE

The statutory autumn meeting of the Iron and Steel Institute was held on Thursday, November 23, 1939, at the offices of the Institute, 4 Grosvenor Gardens, London, S.W.1. Only formal business was transacted at the meeting. It took the place of the meeting which was to have been held at Cardiff on September 12-15, 1939, but which was cancelled. The Council have announced that the general activities of the Institute will be curtailed in order to release as many of the staff as possible for national service. Until further notice, no general meetings, additional meetings or joint meetings with local societies will be held for the presentation and discussion of papers.

TURKISH CHROME EXPORTS

According to figures received by the Department of Overseas Trade, the value of exports of chrome (ore) from Turkey in July, 1939, reached £T642,000 as compared with £T521,000 for the same month in 1938. Total exports from Turkey to the United Kingdom, however, for the same months decreased from £T304,000 to £T198,000, while those to Germany rose from £T1,393,000 to £T4,605,000.

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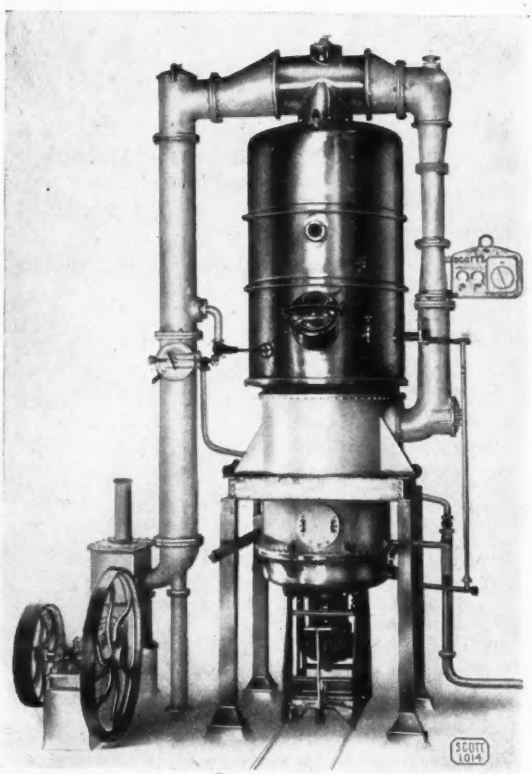

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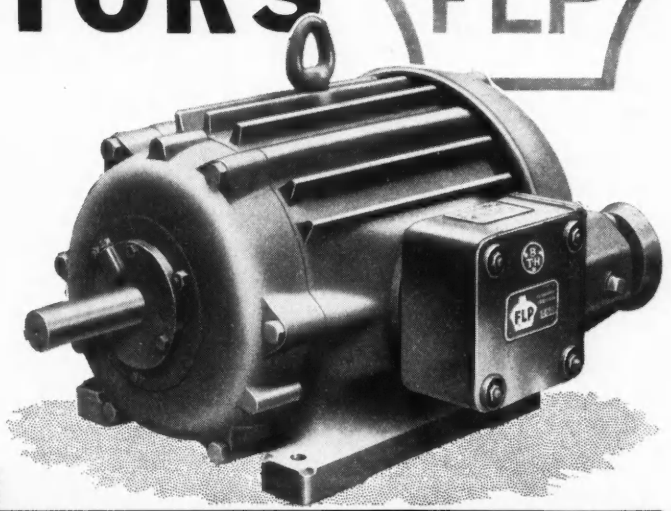

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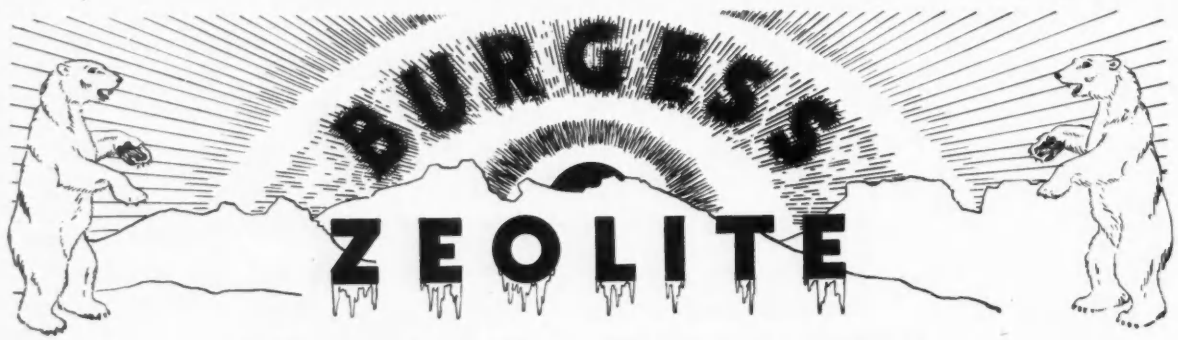

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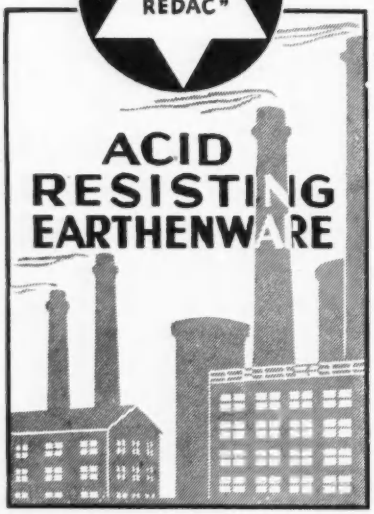

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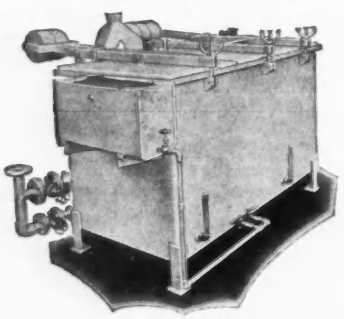

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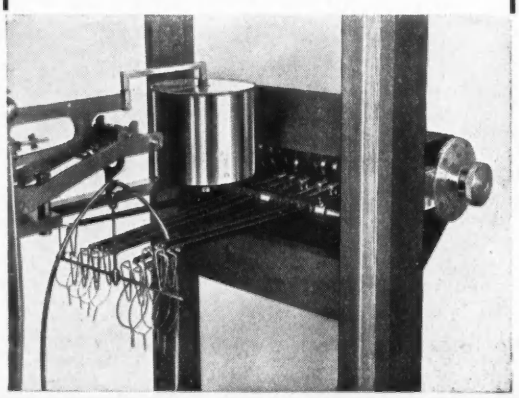

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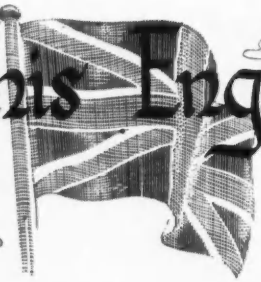

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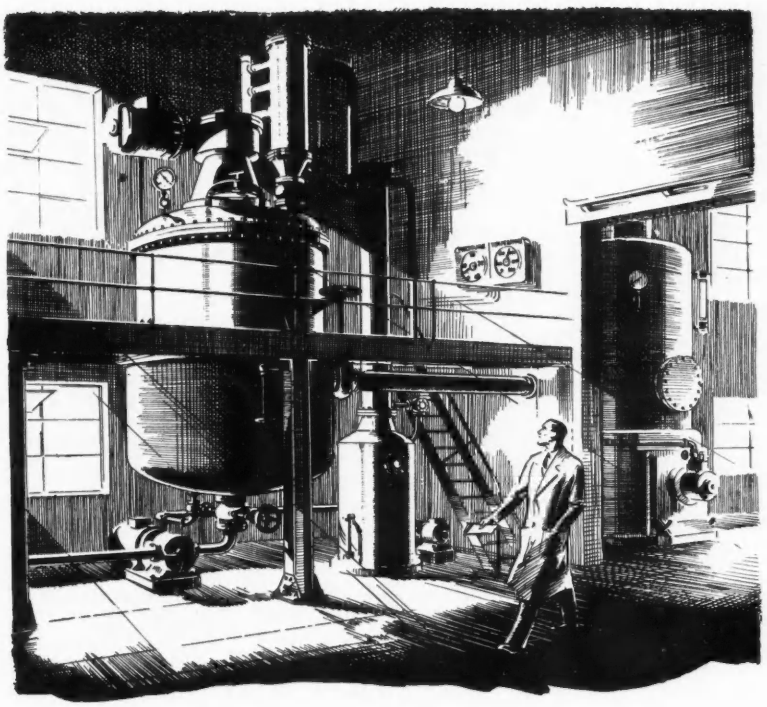

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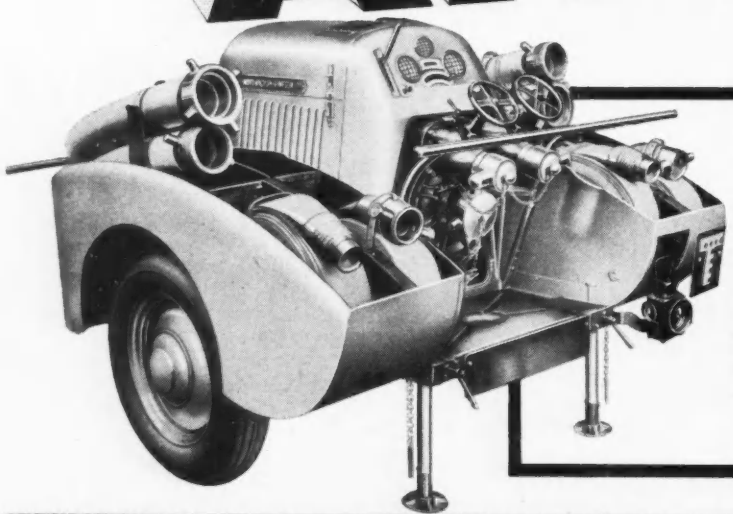

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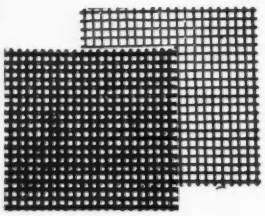

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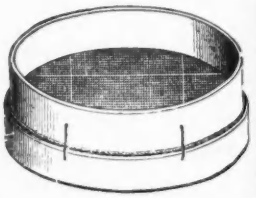

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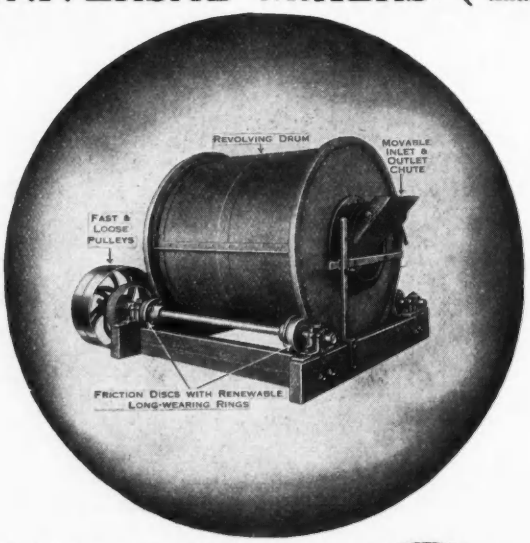

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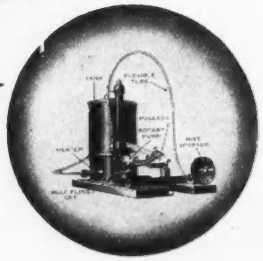

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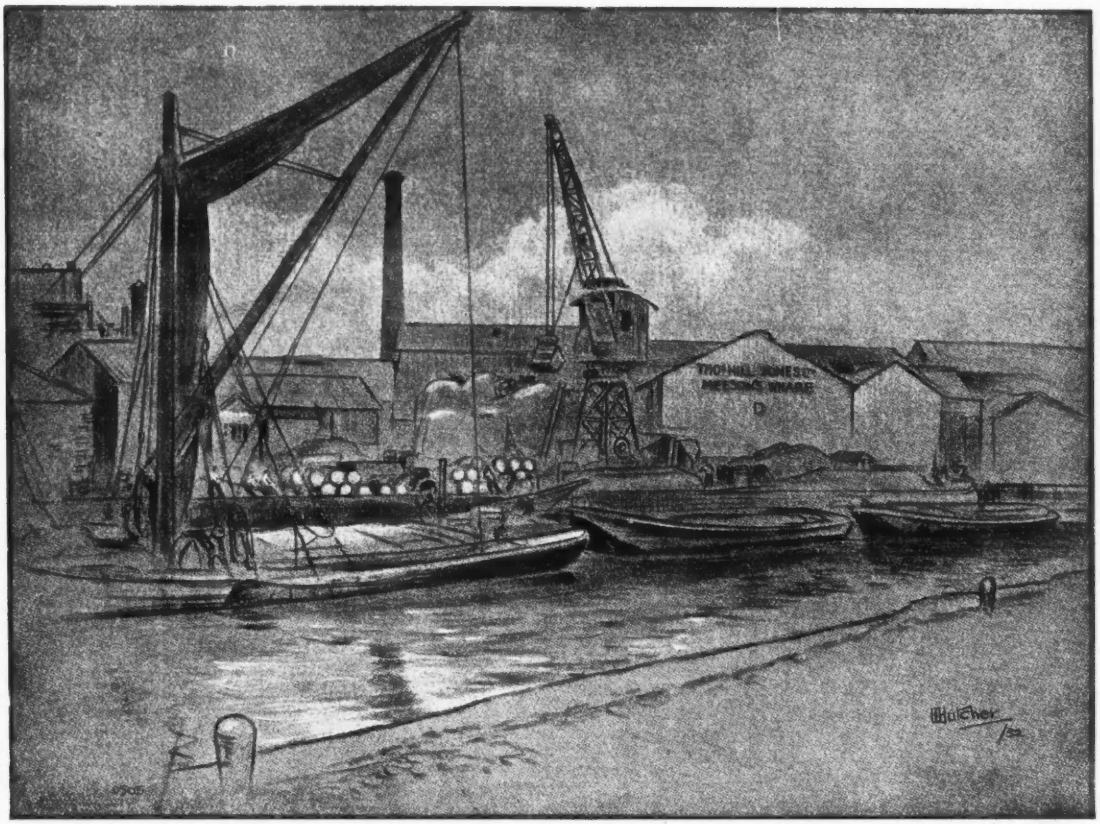

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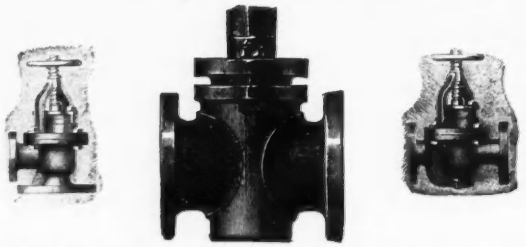
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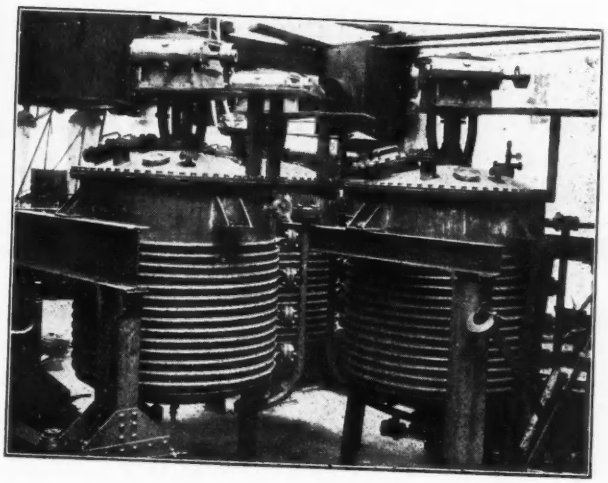

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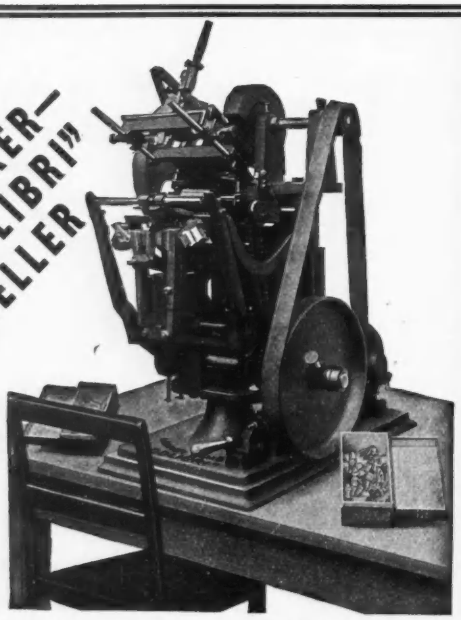

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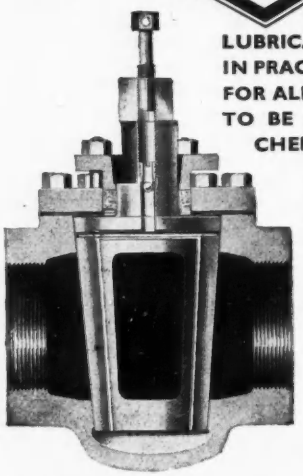

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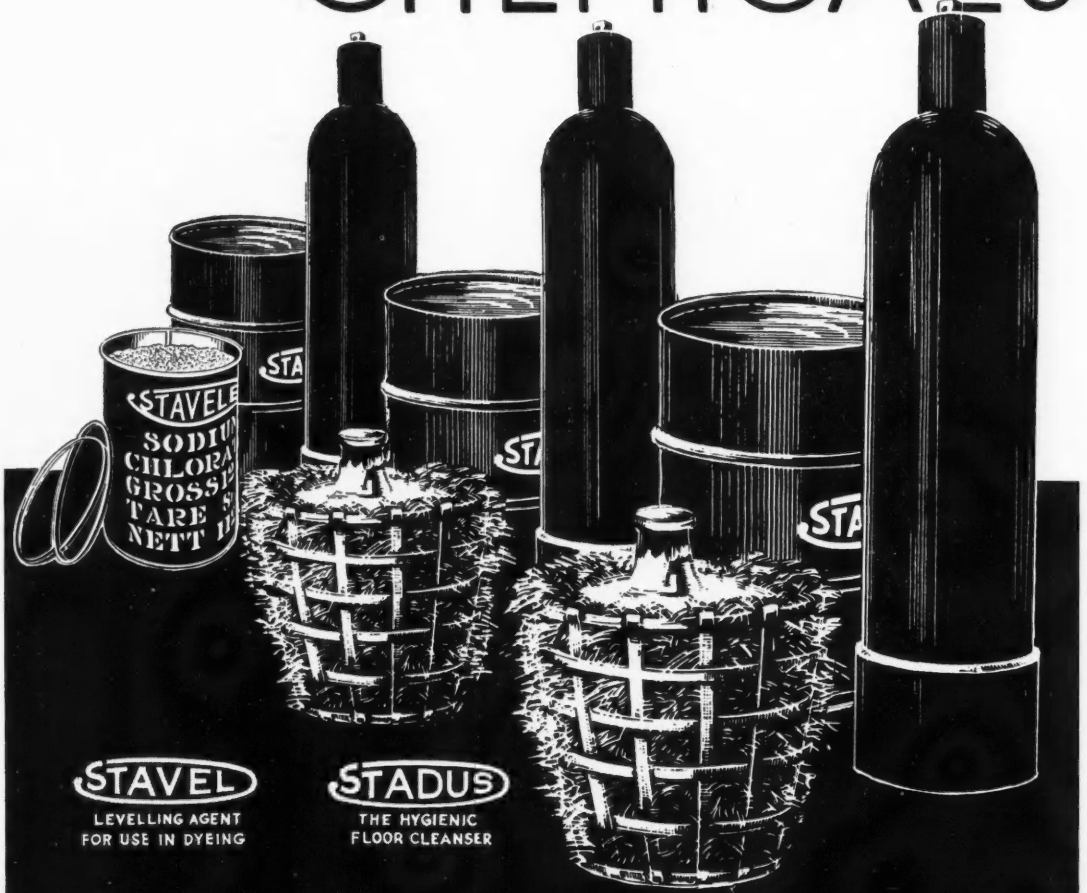

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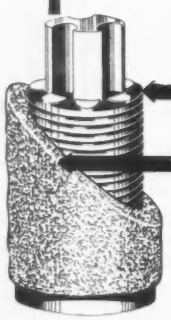

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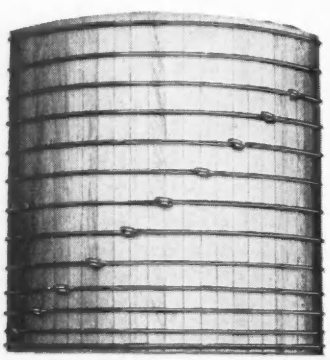

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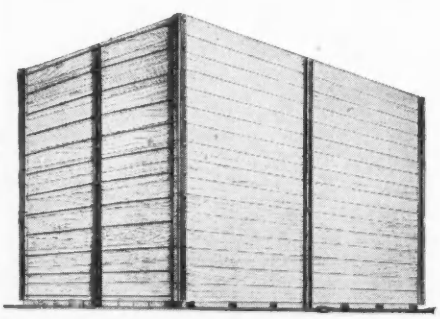

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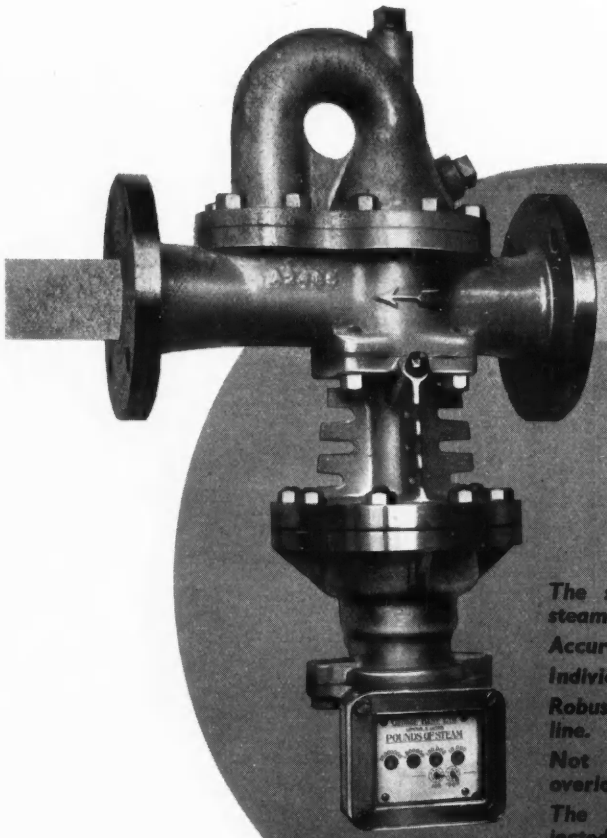

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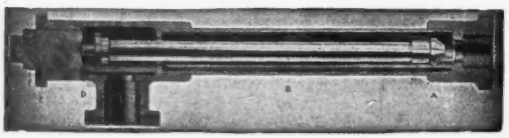

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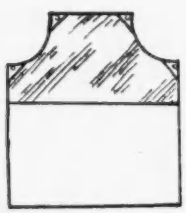

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